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Sergyeyenko et al.

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(54) **BATTERY PACK CHARGER SYSTEM**

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(73) Assignee: **Black & Decker Inc.**, New Britain, CT (US)

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This patent is subject to a terminal disclaimer.

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Related U.S. Application Data

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(51) **Int. Cl.**
H02J 7/00 (2006.01)

(52) **U.S. Cl.**
CPC ***H02J 7/0013*** (2013.01); ***H02J 7/007*** (2013.01); ***H02J 7/0045*** (2013.01); ***H02J 7/0047*** (2013.01); *H02J 7/0049* (2020.01)

(58) **Field of Classification Search**
CPC H02J 7/0013; H02J 7/0045; H02J 7/0047; H02J 7/0049; H02J 7/007
USPC 320/107, 111, 113, 134
See application file for complete search history.

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Assistant Examiner — Aaron Piggush
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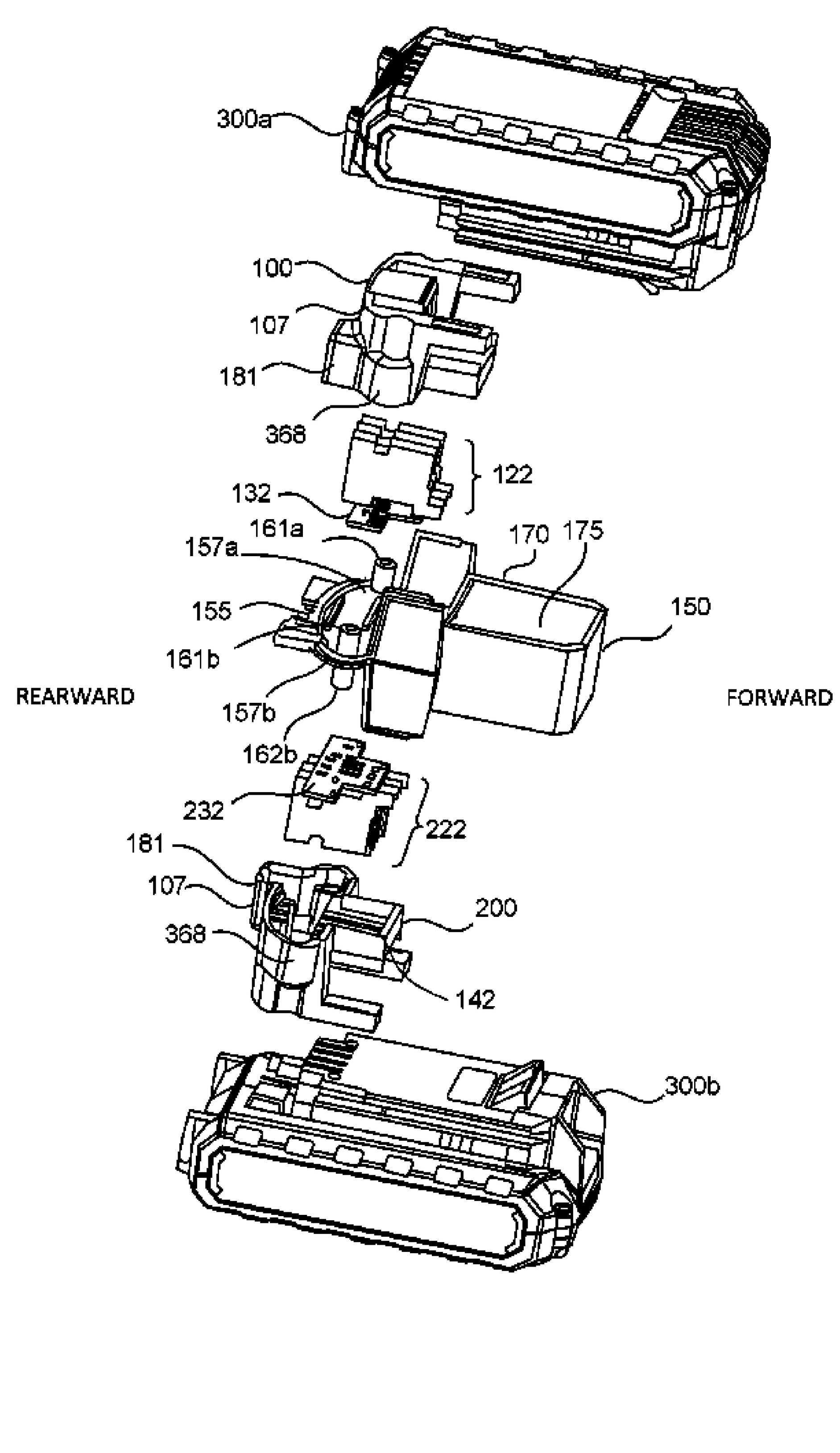
(57) **ABSTRACT**

A battery pack charger system may include a first charger configured to charge a first battery pack, a second charger configured to charge a second battery pack, a support arranged between the first charger and the second charger, and a power cord configured to deliver power. The first charger may be attached on a first side of the support and the second charger may be attached on a second side of the support that is opposite the first side of the support. The first charger and the second charger may be arranged directly opposite of each other. The power cord may be connected to one of the first charger or the second charger.

10 Claims, 16 Drawing Sheets



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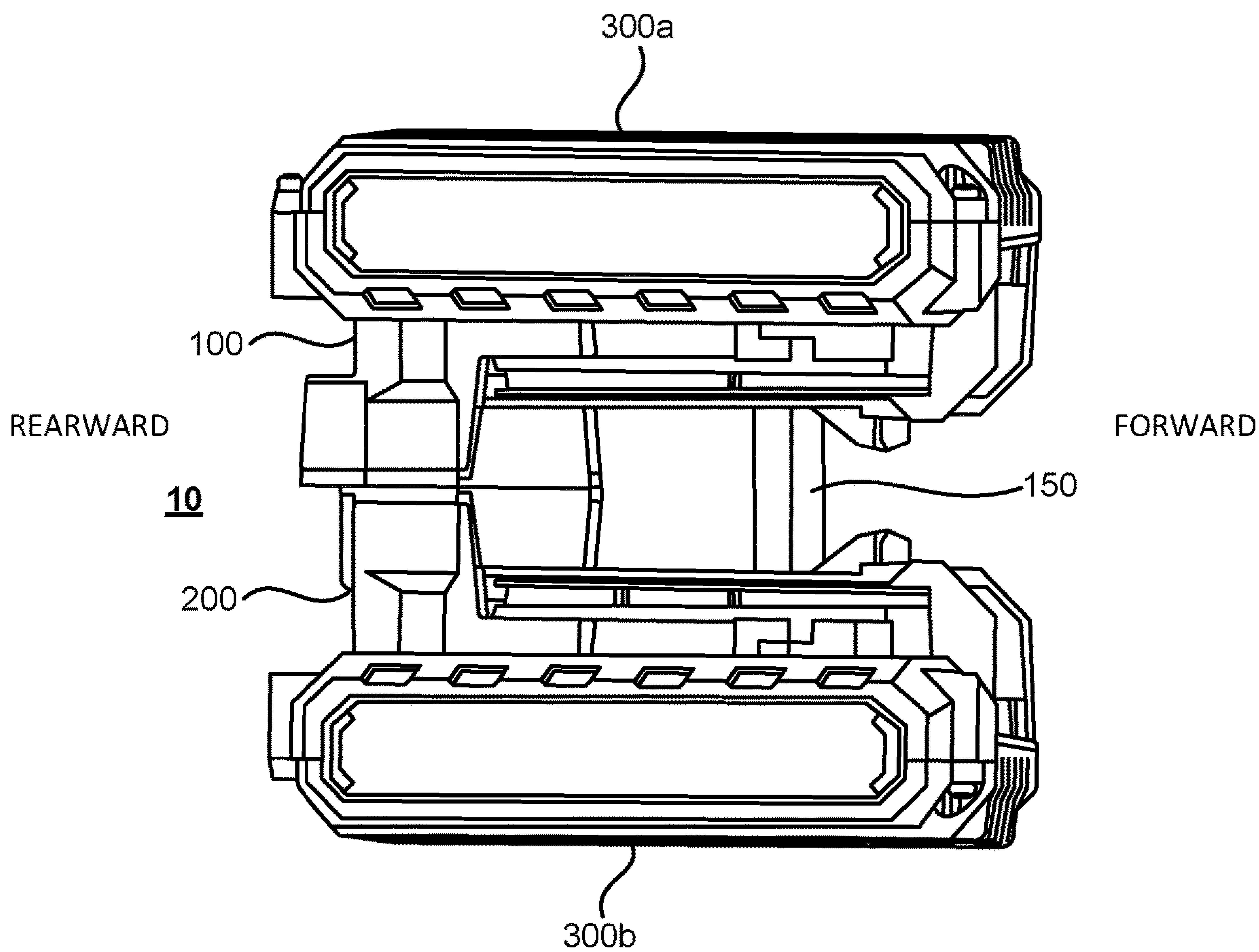


FIG. 1

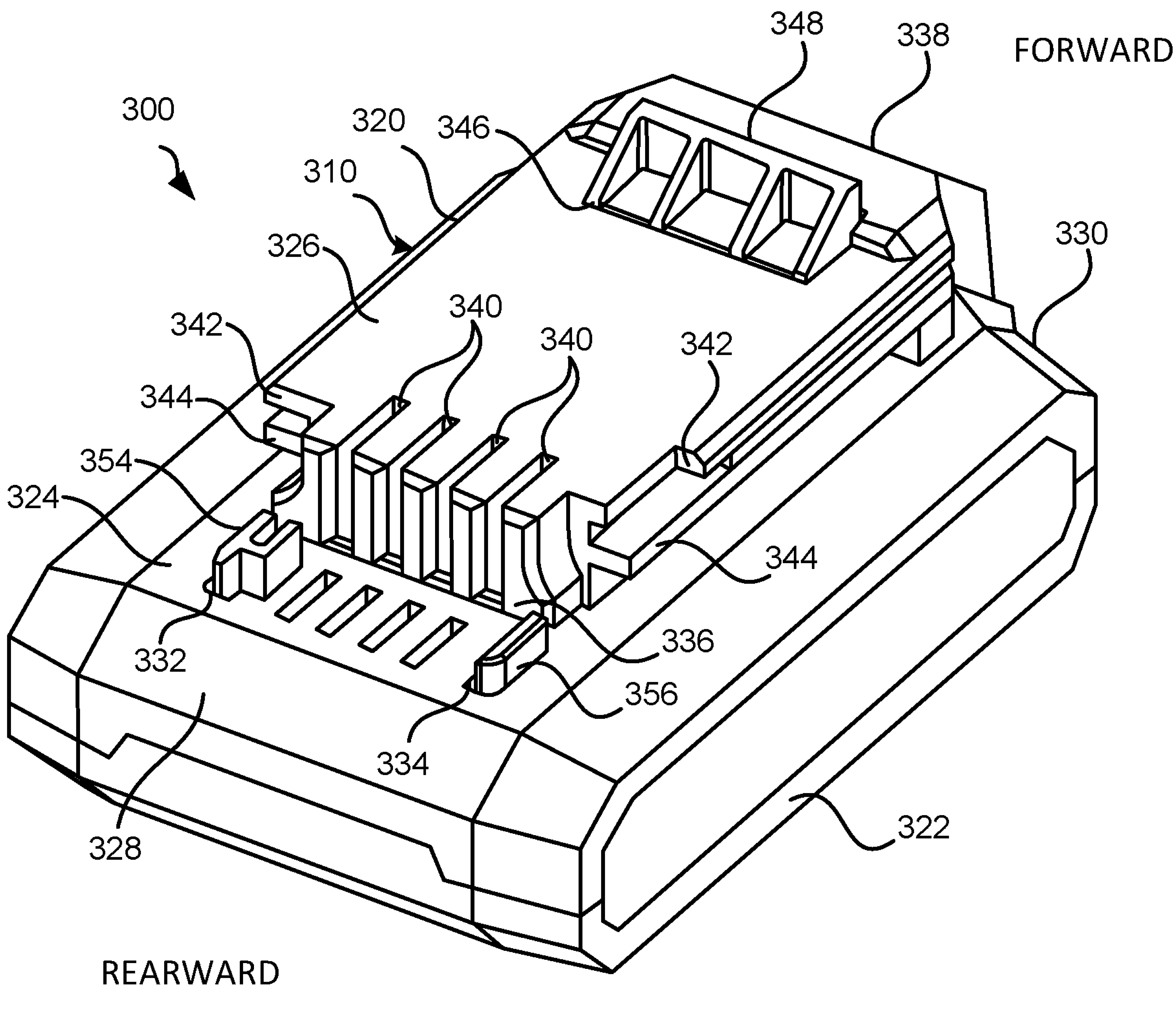

348
338
FORWARD
300
320
346
310
330
326
340
340
342
342
344
354
324
344
336
332
356
334
322
328
REARWARD

FIG. 2

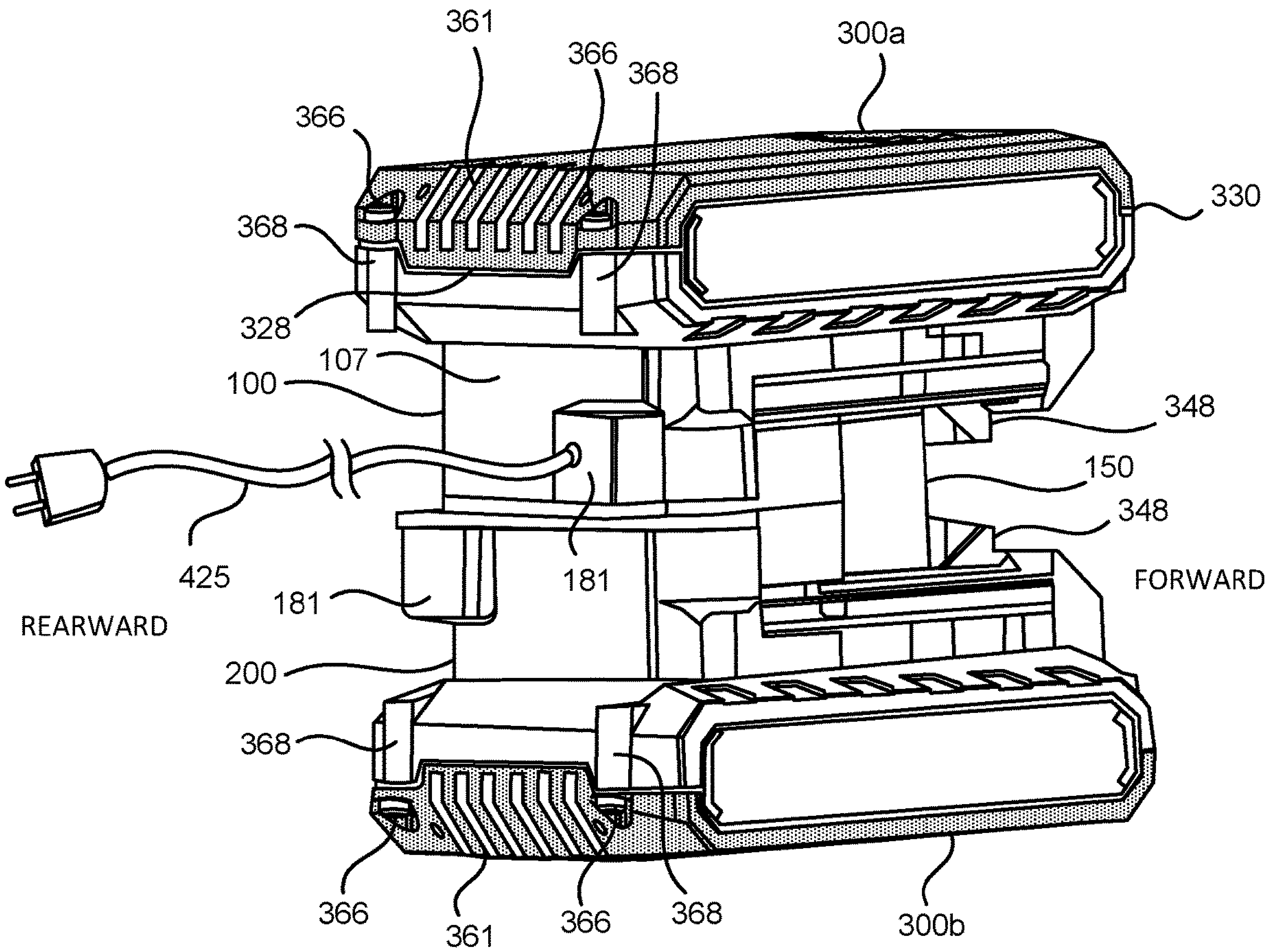
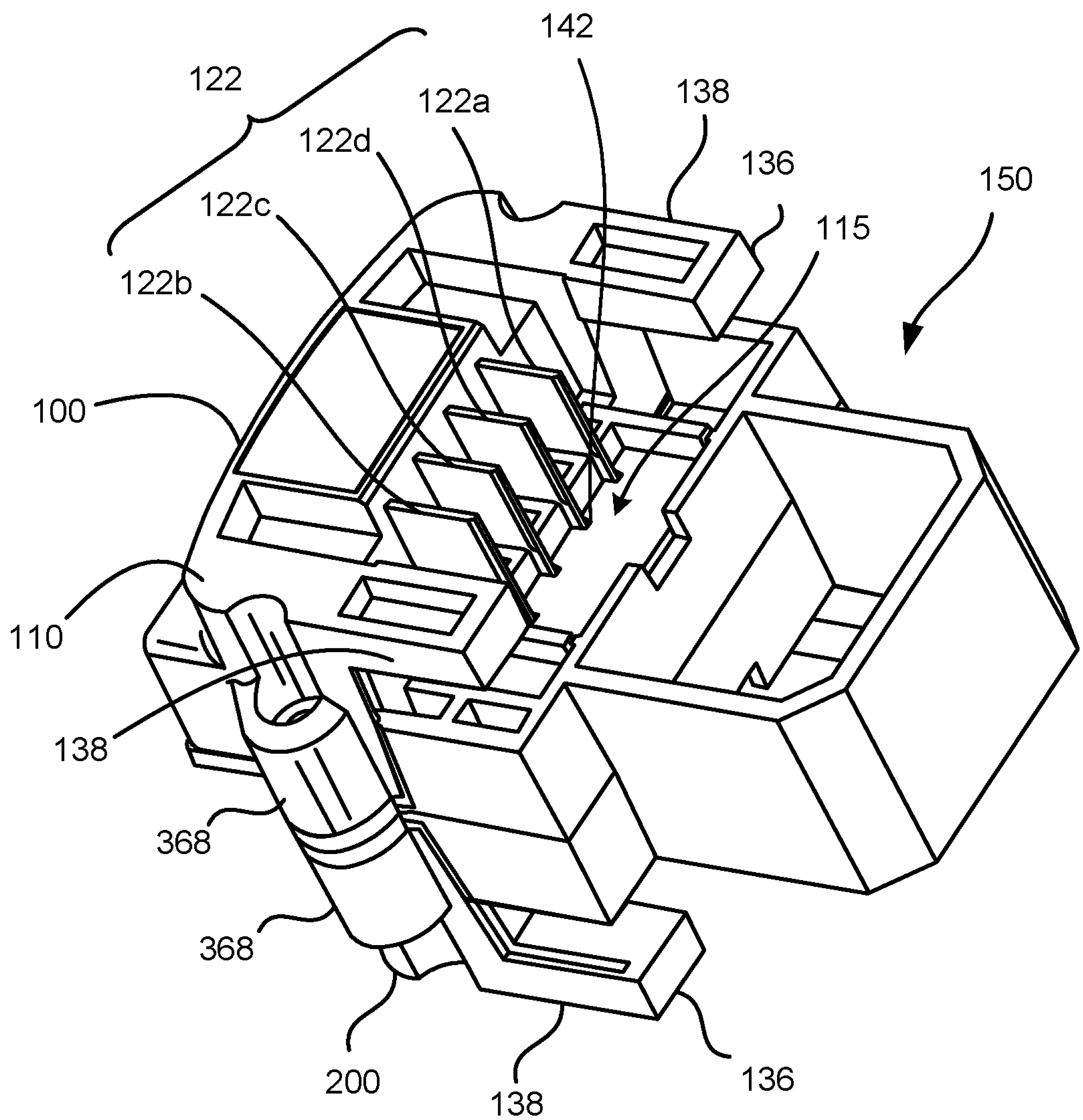

361
366
368
300a
366
330
368
328
107
100
348
150
348
425
181
FORWARD
181
REARWARD
200
368
366
361
366
368
300b

FIG. 3



122
142
122a
138
122d
136
122c
115
150
122b
100
110
138
368
368
200
138
136

FIG. 4

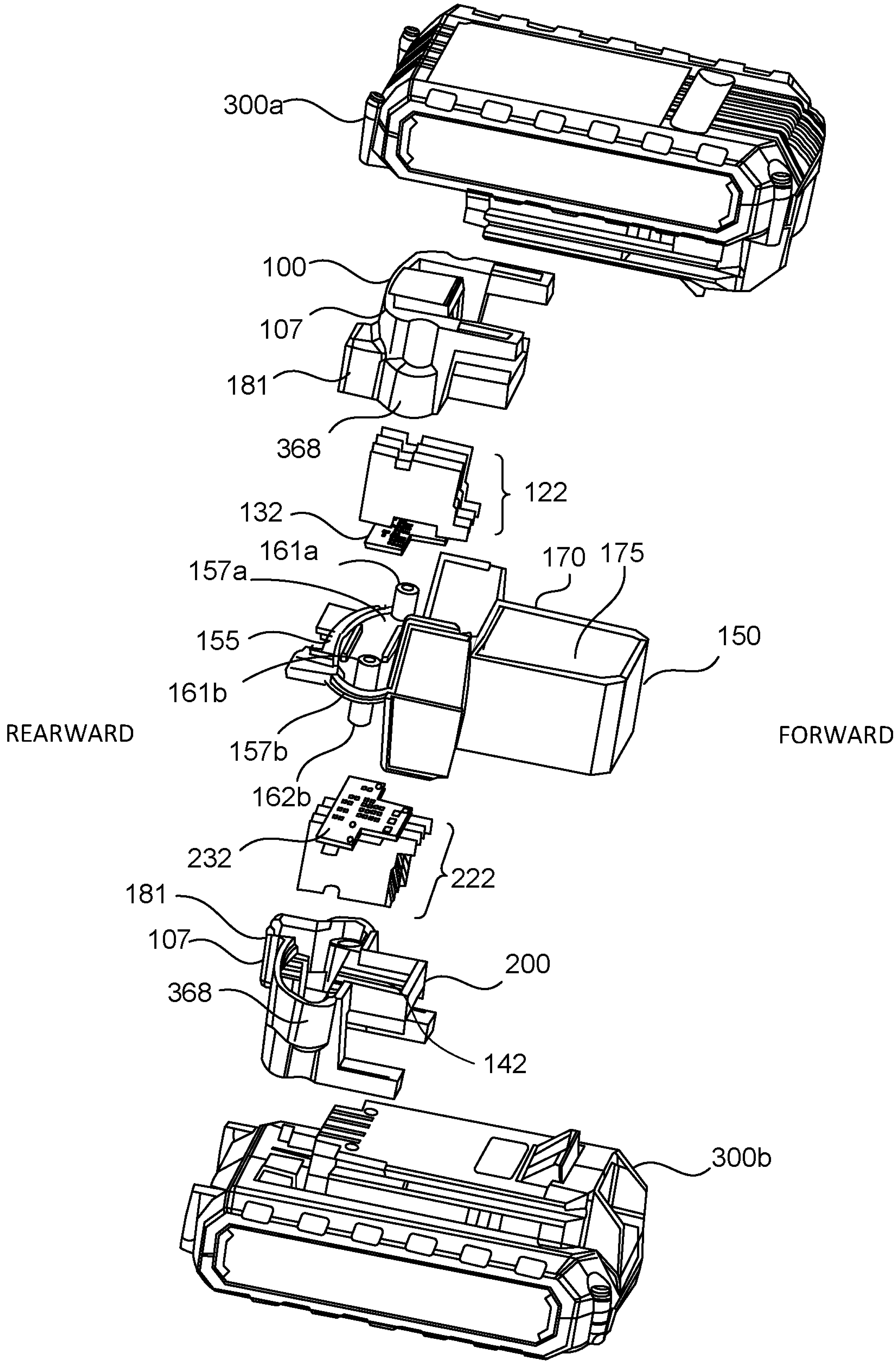

300a
100
107
181
368
122
132
161a
157a
170
175
155
150
161b
REARWARD
FORWARD
157b
162b
232
222
181
107
200
368
142
300b

FIG. 5

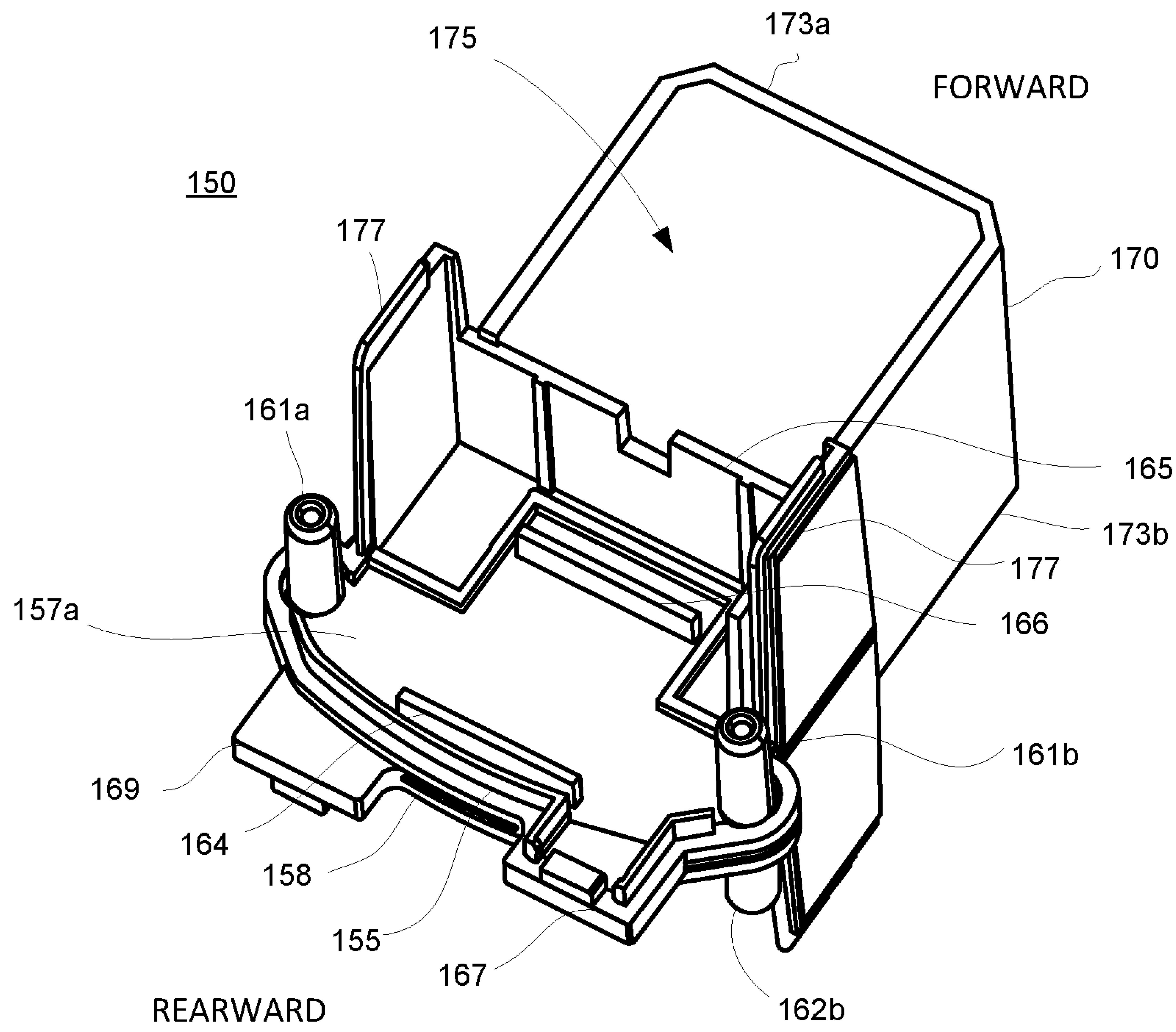

175
173a
FORWARD
150
177
170
161a
165
173b
177
157a
166
161b
169
164
158
155
167
162b
REARWARD

FIG. 6A

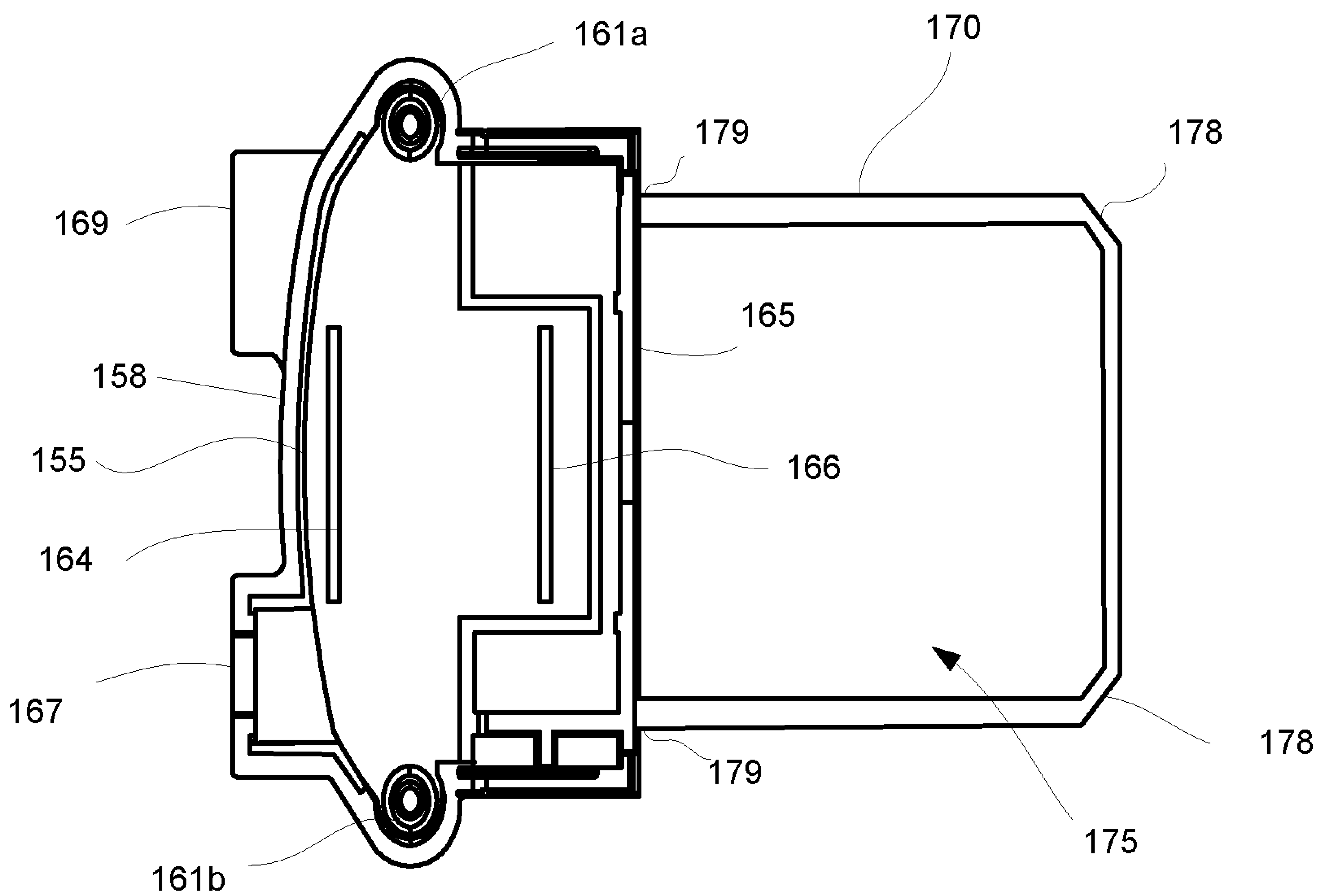

161a
170
179
178
169
165
158
155
166
164
167
178
179
175
161b

FIG. 6B

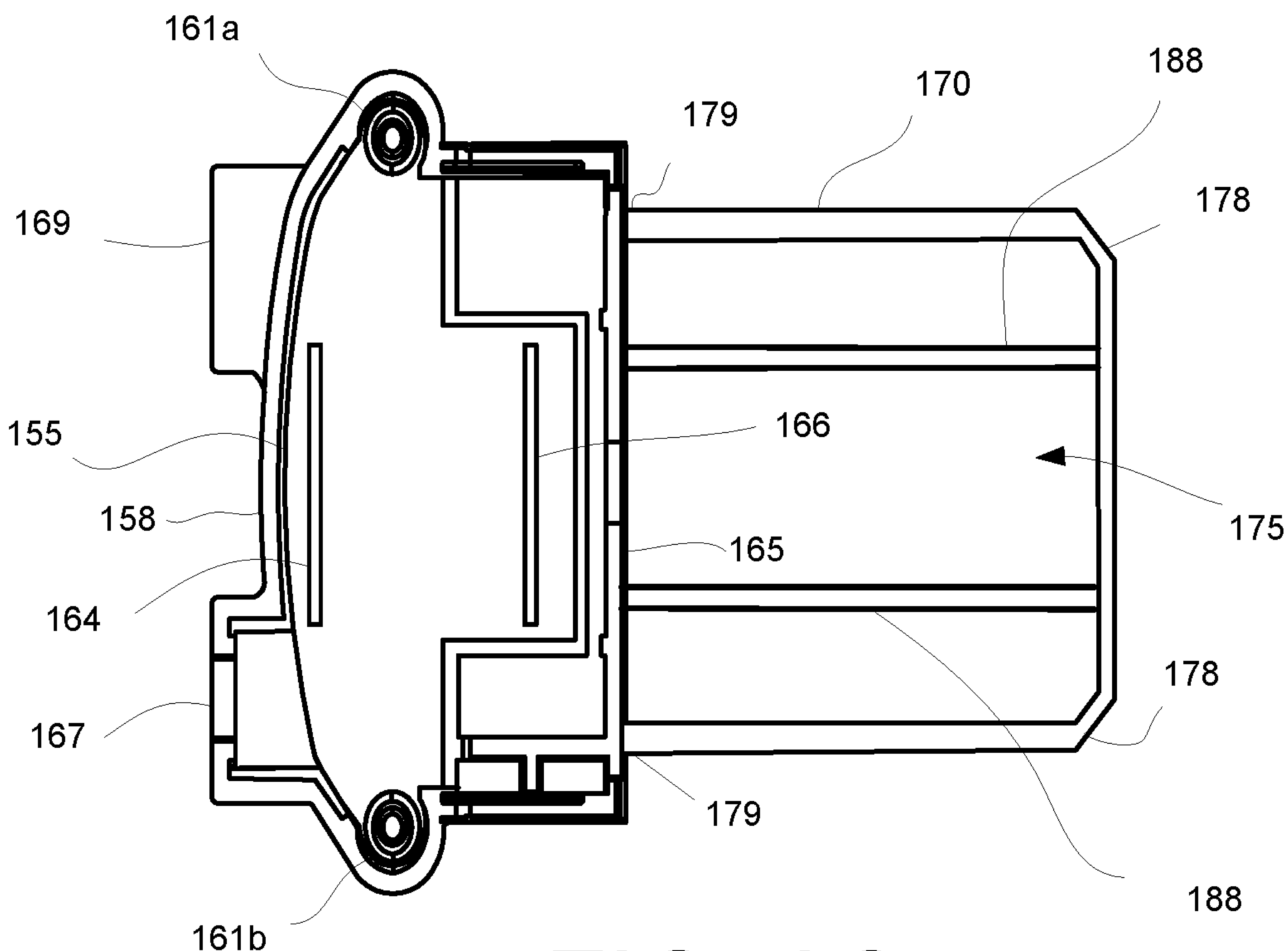

161a
188
170
179
178
169
155
166
158
175
165
164
178
167
179
188
161b

FIG. 6C

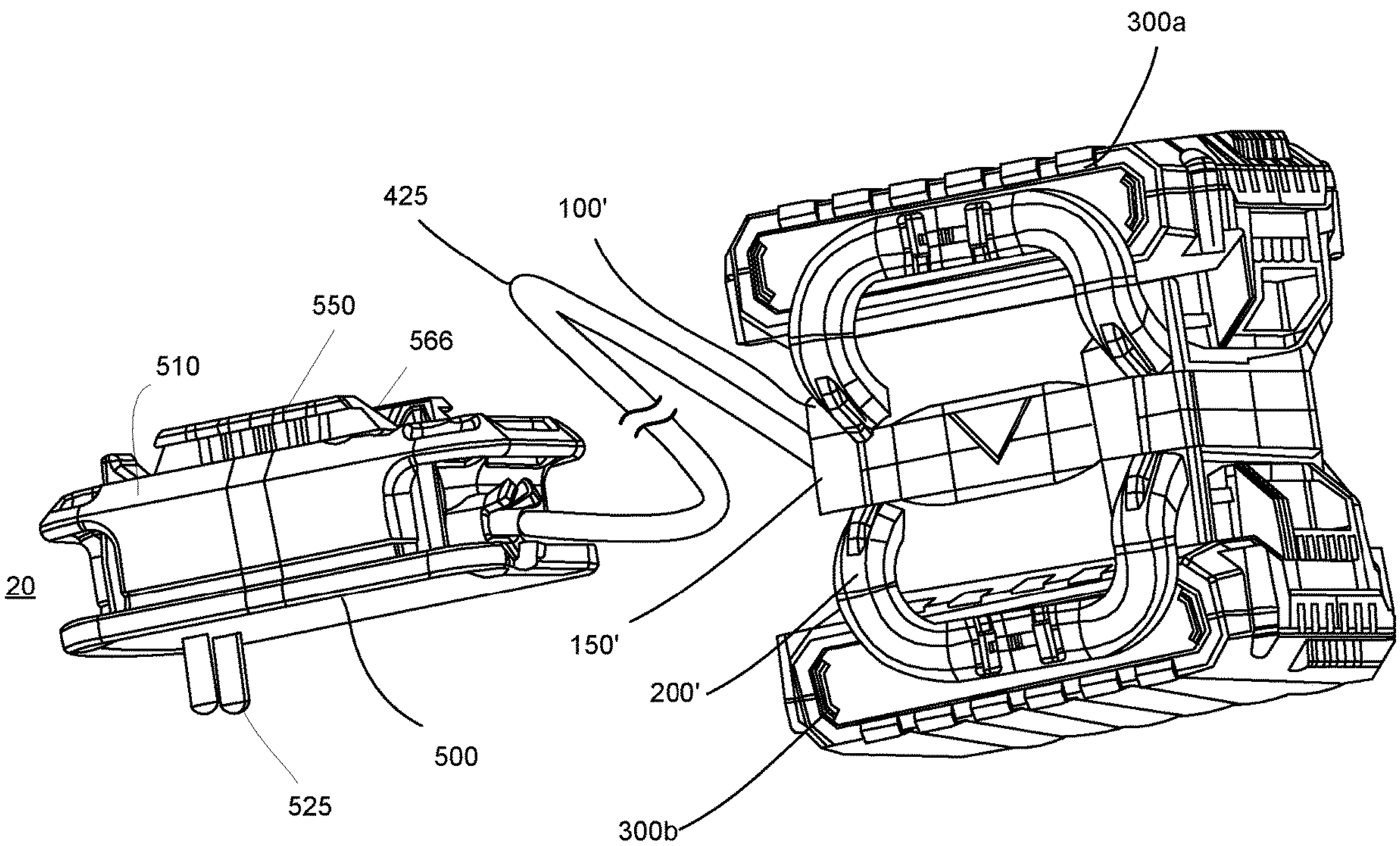


FIG. 7

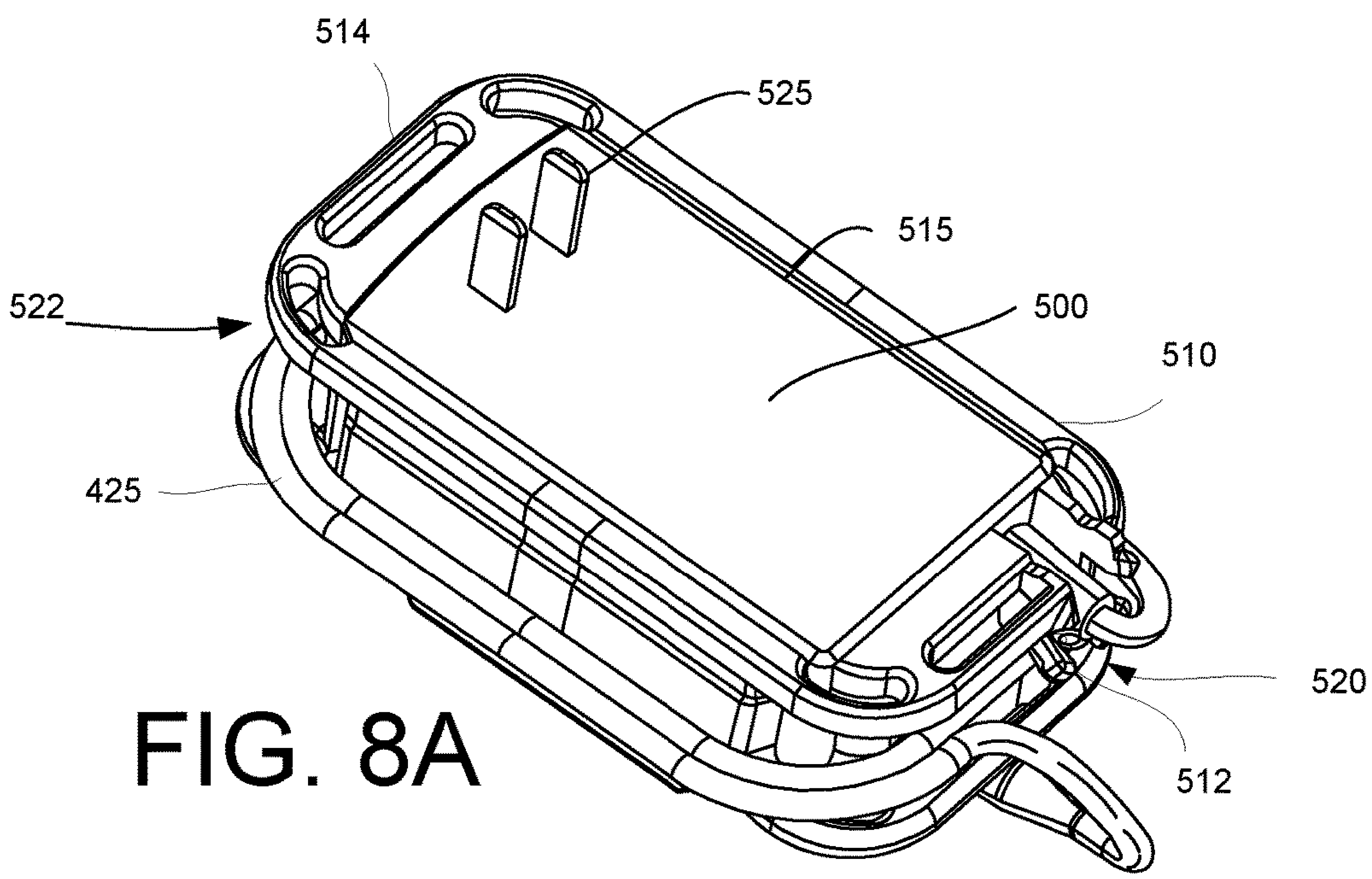

514
525
515
522
500
510
425
520
512

FIG. 8A

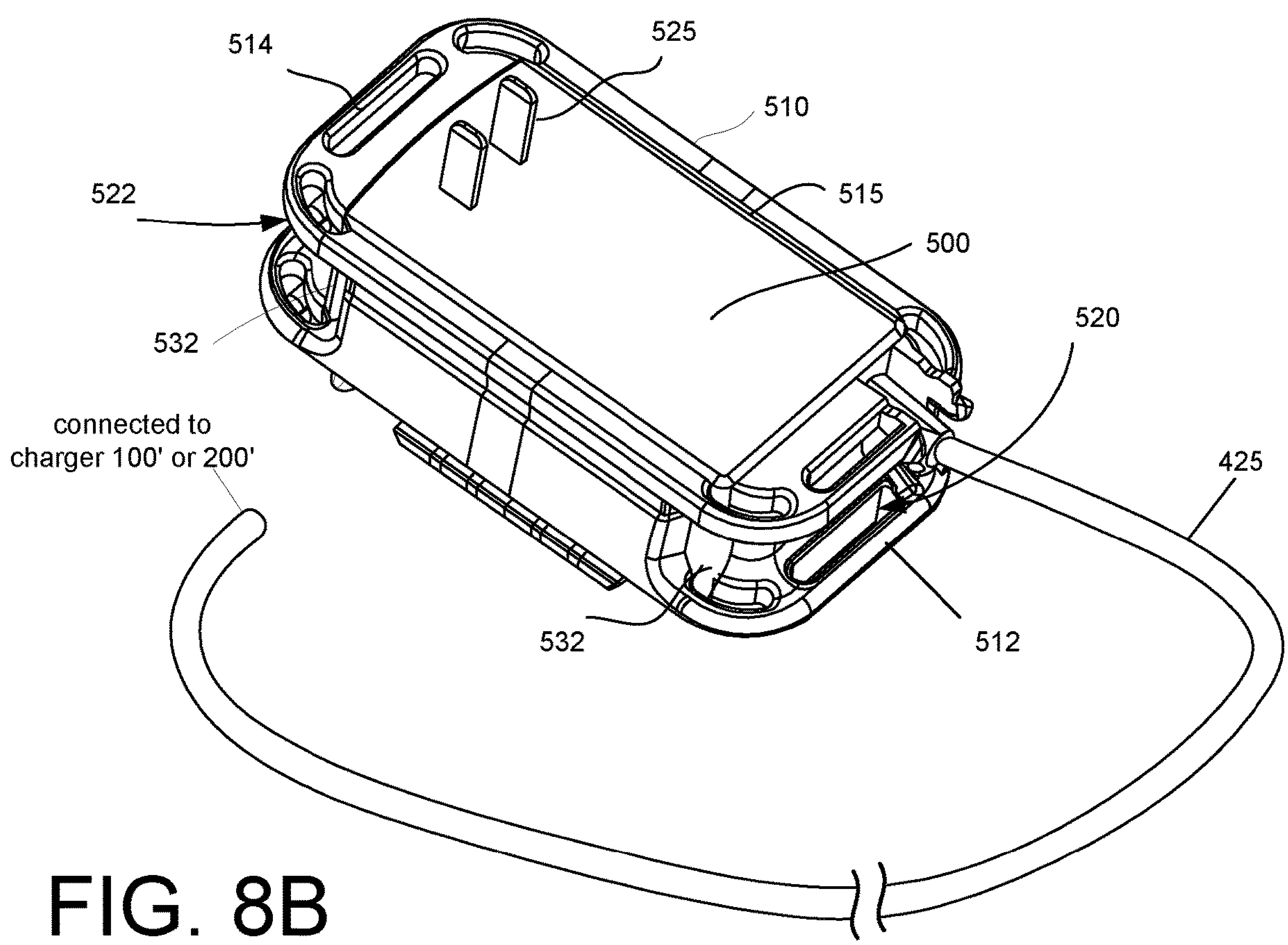

514
525
510
522
515
500
532
520
connected to
charger 100' or 200'
425
532
512

FIG. 8B

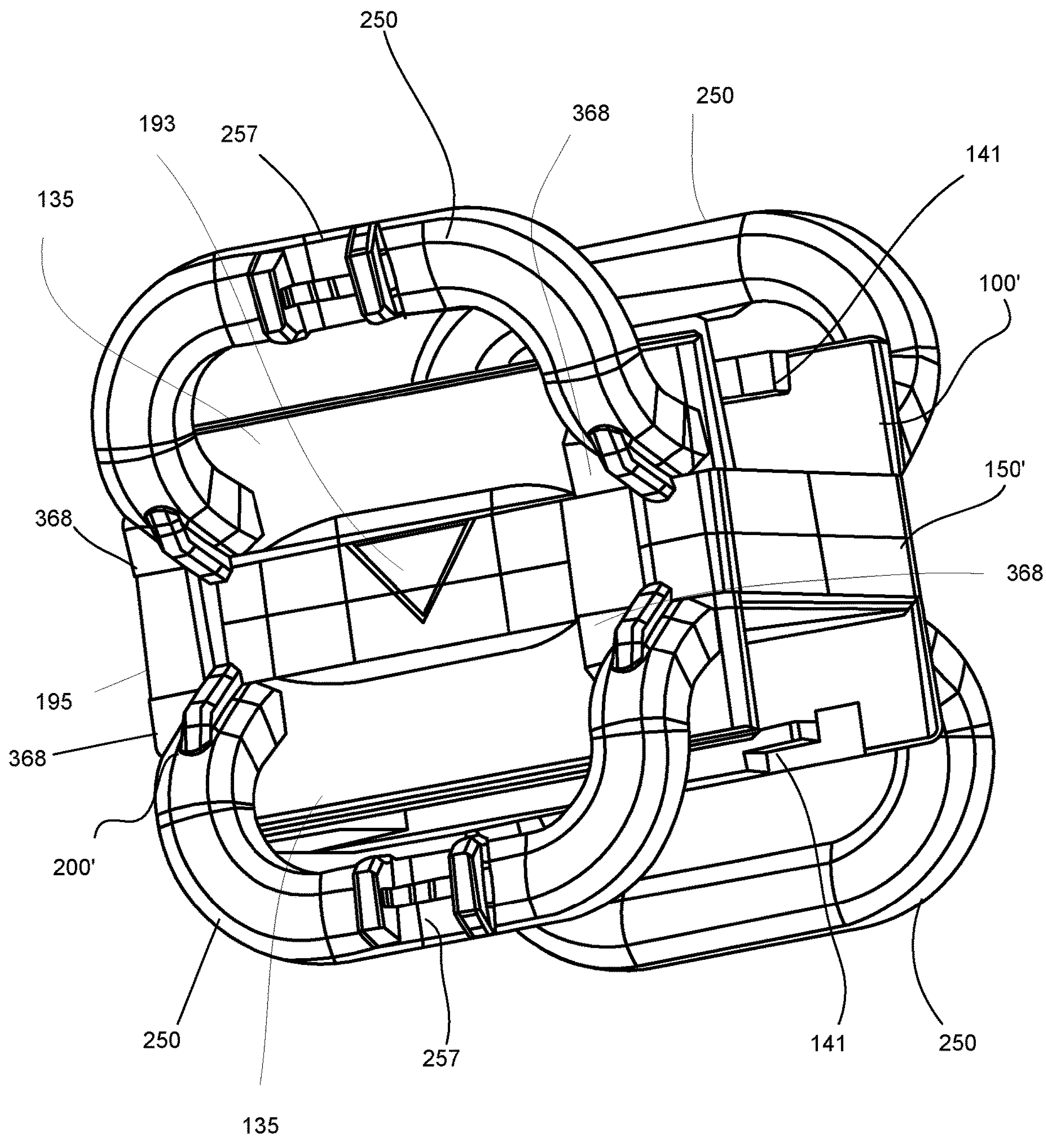

250
368
250
193
257
141
135
100'
150'
368
368
195
368
200'
250
257
141
250
135

FIG. 9

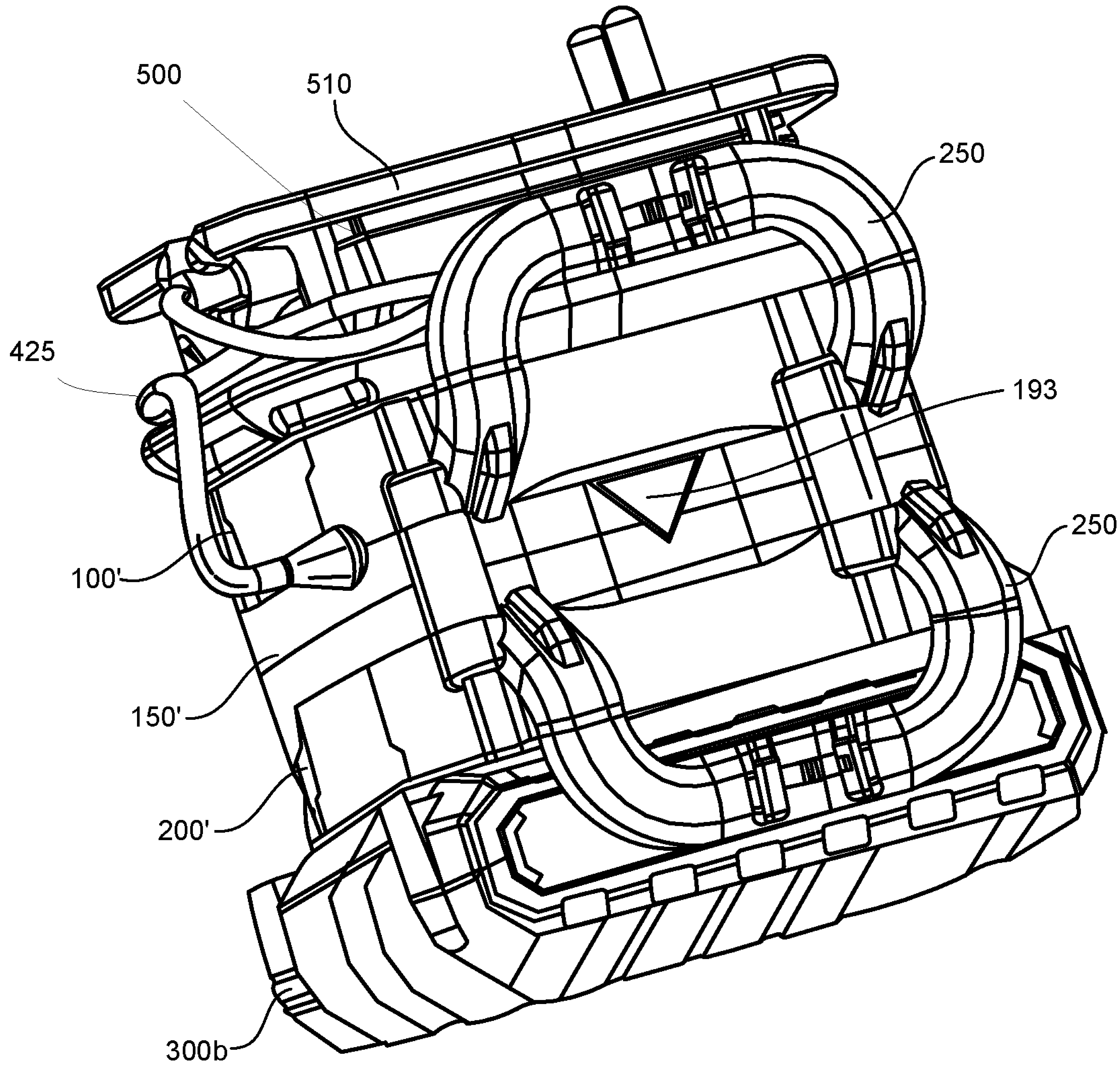


FIG. 10

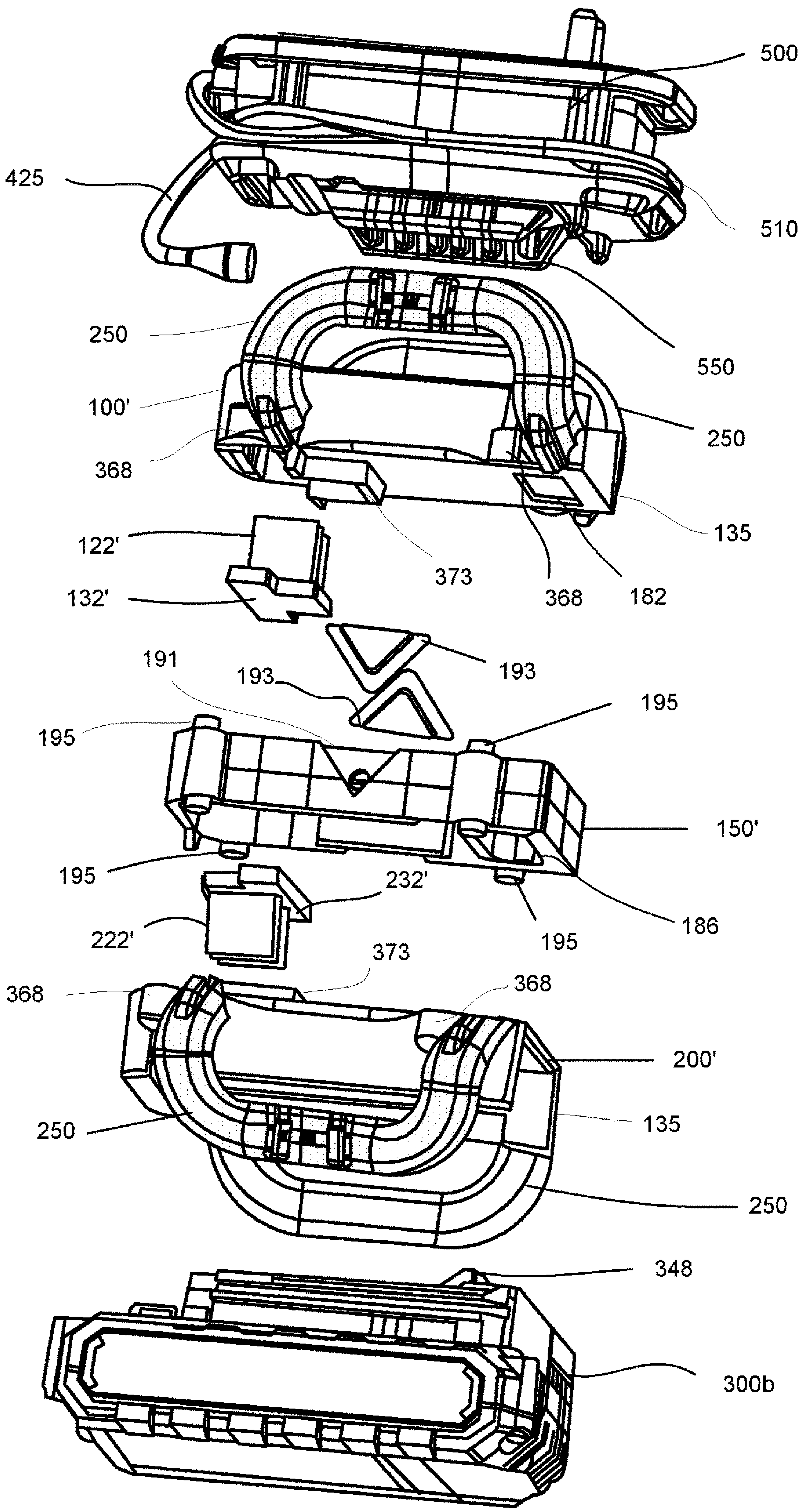

500
425
510
250
550
100'
250
368
135
122'
373
368
182
132'
193
191
193
195
195
195
150'
195
232'
222'
195
186
373
368
368
200'
250
135
250
348
300b

FIG. 11

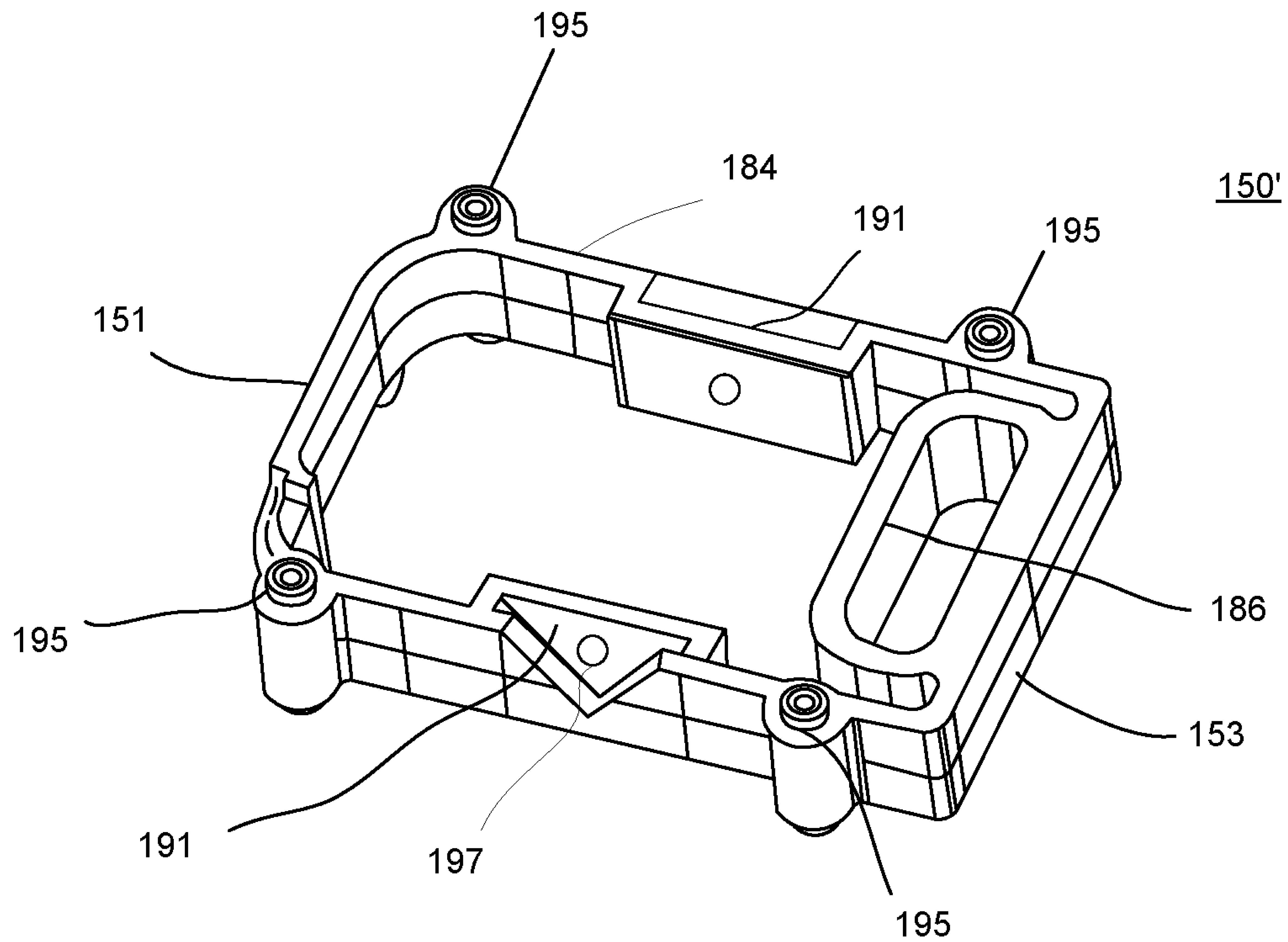


FIG. 12A

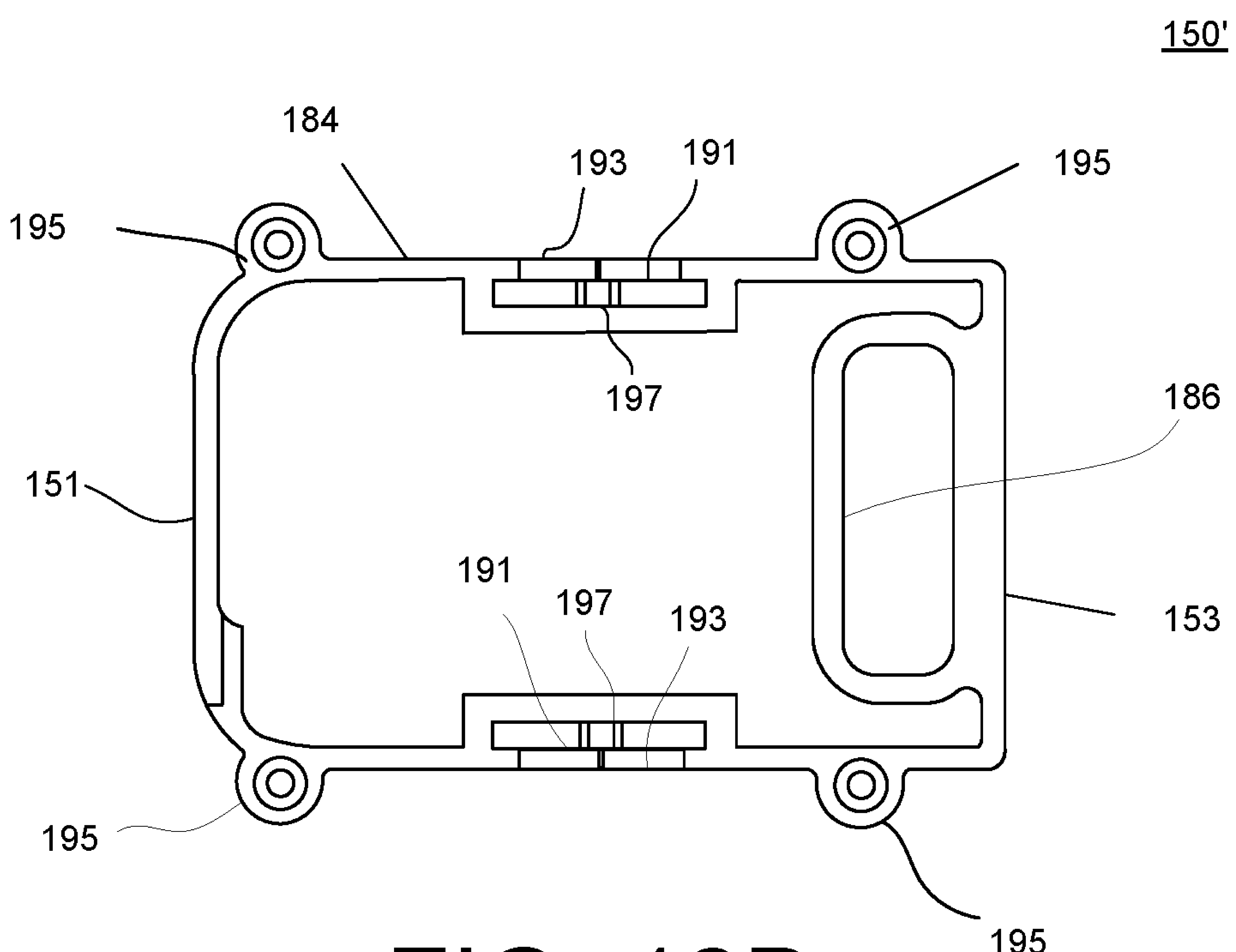
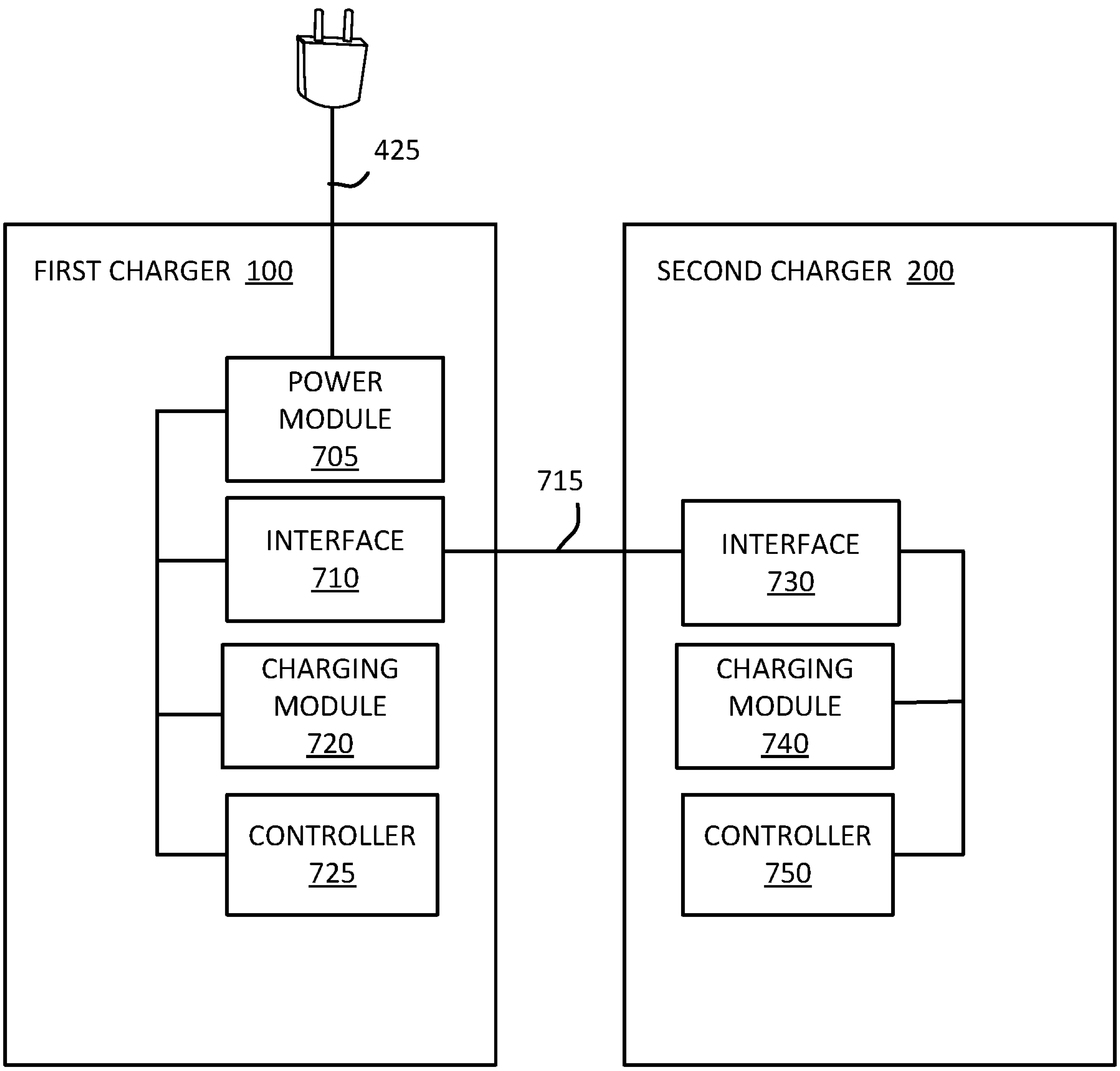


FIG. 12B



425
FIRST CHARGER 100
POWER MODULE 705
INTERFACE 710
CHARGING MODULE 720
CONTROLLER 725
715
SECOND CHARGER 200
INTERFACE 730
CHARGING MODULE 740
CONTROLLER 750

FIG. 13

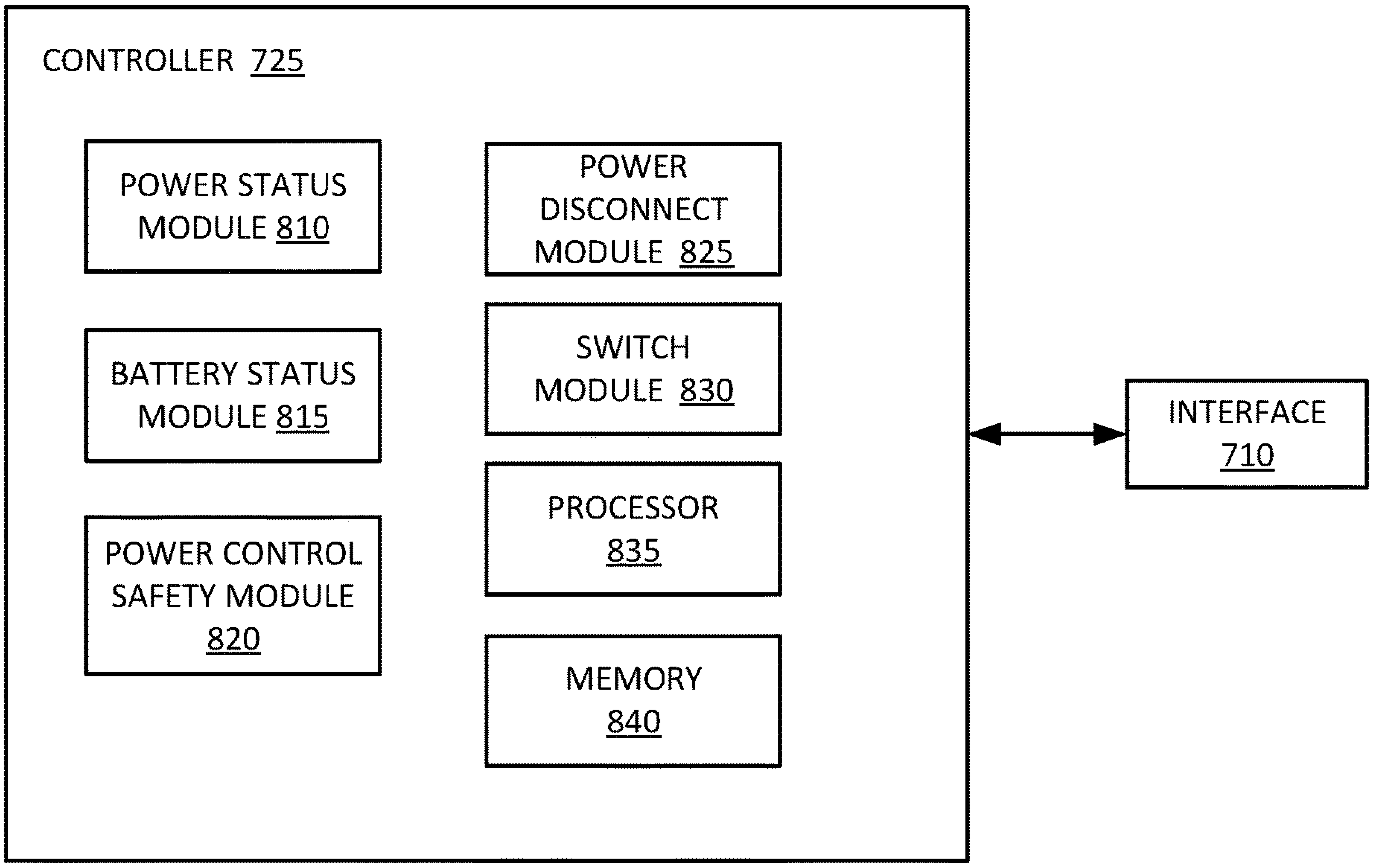

CONTROLLER 725
POWER STATUS MODULE 810
BATTERY STATUS MODULE 815
POWER CONTROL SAFETY MODULE 820
POWER DISCONNECT MODULE 825
SWITCH MODULE 830
PROCESSOR 835
MEMORY 840
INTERFACE 710

FIG. 14

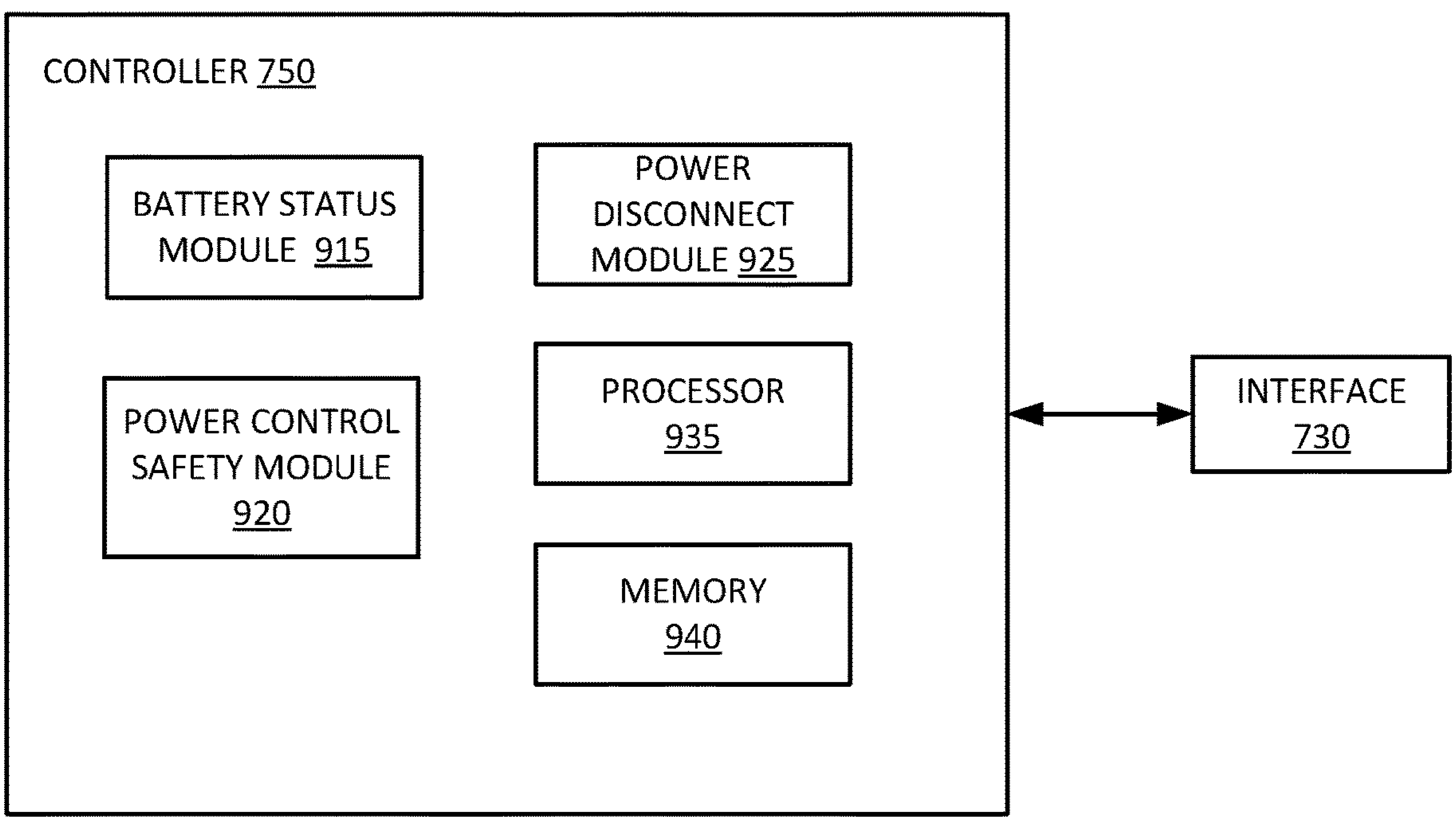
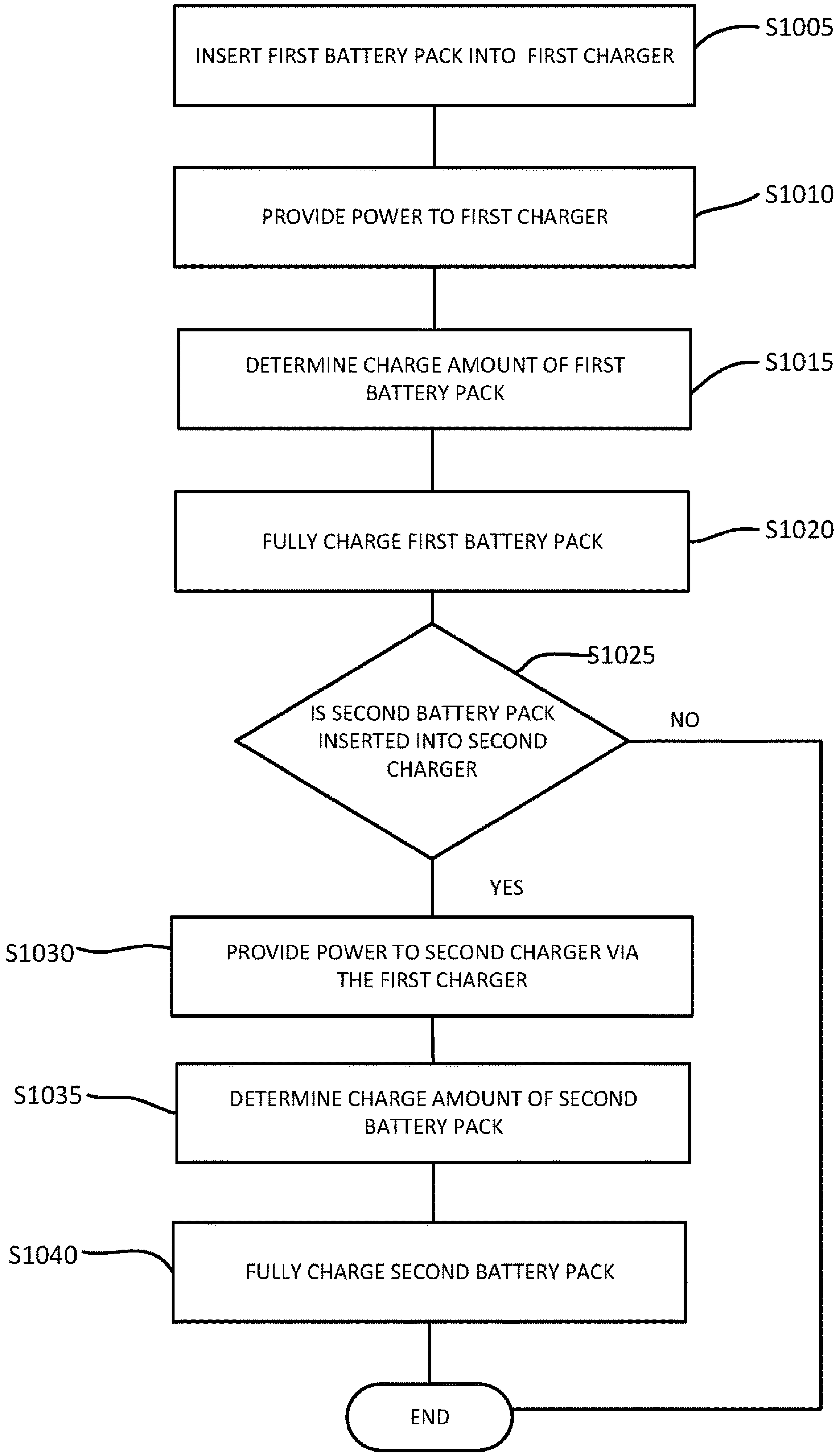

CONTROLLER 750
BATTERY STATUS MODULE 915
POWER CONTROL SAFETY MODULE 920
POWER DISCONNECT MODULE 925
PROCESSOR 935
MEMORY 940
INTERFACE 730

FIG. 15



INSERT FIRST BATTERY PACK INTO FIRST CHARGER
S1005
PROVIDE POWER TO FIRST CHARGER
S1010
DETERMINE CHARGE AMOUNT OF FIRST BATTERY PACK
S1015
FULLY CHARGE FIRST BATTERY PACK
S1020
S1025
IS SECOND BATTERY PACK INSERTED INTO SECOND CHARGER
NO
YES
S1030
PROVIDE POWER TO SECOND CHARGER VIA THE FIRST CHARGER
S1035
DETERMINE CHARGE AMOUNT OF SECOND BATTERY PACK
S1040
FULLY CHARGE SECOND BATTERY PACK
END

FIG. 16

BATTERY PACK CHARGER SYSTEM

CROSS-REFERENCE TO RELATED APPLICATION

This application is a continuation application and claims the benefit of U.S. application Ser. No. 15/687,179, filed on Aug. 25, 2017, and titled "Battery Pack Charger System," which is incorporated herein by reference in its entirety.

TECHNICAL FIELD

This description relates to a battery pack charger system.

BACKGROUND

Users of cordless devices discharge their battery packs faster than they can charge them. Power sources (e.g., AC outlet, DC cigarette lighter outlet, etc.) for charging the battery packs are often unavailable or limited and/or do not provide enough power and energy to keep up with demand.

SUMMARY

In one general aspect, a battery pack charger system may include a first charger configured to charge a first battery pack, a second charger configured to charge a second battery pack, a support arranged between the first charger and the second charger, and a power cord configured to deliver power. The first charger may be attached on a first side of the support and the second charger may be attached on a second side of the support that is opposite the first side of the support. The first charger and the second charger may be arranged directly opposite of each other. The power cord may be connected to one of the first charger or the second charger.

Implementations may include one or more of the following features. For example, the support may include a platform configured to support the first charger on the first side and the second charger on the second side, and a projecting part configured to support the first battery pack on the first side and the second battery pack on the second side. The projecting part may separate the first battery pack and the second battery pack from each other. The projecting part may extend away from the platform in relation to a longitudinal direction of the first battery pack and the second battery pack. The platform may include a first pair of pedestals on the first side to connect to a pair of screw bosses formed on the first charger and a second pair of pedestals on the second side to connect to a pair of screw bosses formed on the second charger. The first charger may include a first connecting structure and the second charger may include a second connecting structure that is same as the first connecting structure. The first connecting structure may include guide rails configured to engage corresponding guide rails of a slide-on style battery pack, and the second connecting structure may include guide rails configured to engage corresponding guide rails of a slide-on style battery pack.

The first charger may include a controller (control circuit) configured to receive and deliver power associated with the first battery pack, determine an amount of charge of the first battery pack, and supply a charge to the first battery pack. The second charger may include a controller (control circuit) configured to deliver power to the second charger via the first charger, determine an amount of charge of the second battery pack, and supply a charge to the second battery pack.

The battery pack charger system may further include a power brick. The power brick may be attached to one of the first charger or the second charger. The power brick may be encased in a casing to protect the power brick. The casing may include a pair of guide rails to correspondingly engage with guide rails of one of the first battery charger or the second battery charger when one of the first battery pack or the second battery pack is removed from the respective first charger or the second charger. The casing may include openings to permit an electrical cord of the power brick to be wrapped within the openings.

In another general aspect, a battery pack charger system may include a first charger, a second charger, a support arranged between the first charger and the second charger, and a power brick configured to deliver power. The first charger may be attached on a first side of the support and the second charger may be attached on a second side of the support that is opposite the first side of the support. The first charger and the second charger may be arranged directly opposite of each other.

Implementations may include one or more of the following features. For example, the power brick may be configured to be connectable to the first charger and/or the second charger, and a battery pack may be configured to be connectable to the other first charger and/or the second charger. Each of the first charger and the second charger may include a housing configured to receive at least one of the power brick and the battery pack, and a pair of reinforcing members. The pair of reinforcing members may extend at sides of the housing. The pair of reinforcing members may include a securing device configured to secure an electrical cord of the power brick.

In another general aspect, a method of forming a battery pack charger system having a first charger and a second charger includes arranging a support between the first charger and the second charger, attaching the first charger to a first side of the support, attaching the second charger to a second side of the support that is opposite the first side, arranging the first charger and the second charger directly opposite of each other, and delivering power via a power cord connected to one of the first charger or the second charger.

The details of one or more implementations are set forth in the accompanying drawings and the description below. Other features will be apparent from the description and drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. **1** is a perspective view of a battery pack charger system in accordance to an example embodiment.

FIG. **2** is a perspective view of a battery pack of the battery pack charger system of FIG. **1**.

FIG. **3** is a different perspective view of the battery pack charger system of FIG. **1**.

FIG. **4** is a perspective view of an exemplary embodiment of a battery pack charger of the battery pack charger system of FIG. **1**.

FIG. **5** is an exploded view of the battery pack charger system of FIG. **1**.

FIG. **6**A is a perspective view of an exemplary embodiment of a support of the battery pack charger system of FIG. **1**.

FIG. **6**B is a top view of the support of FIG. **6**A.

FIG. **6**C is a top view of another exemplary embodiment of a support of the battery pack charger system of FIG. **1**.

FIG. **7** is a perspective view of a battery pack charger system in accordance to another example embodiment.

FIGS. **8**A and **8**B are perspective views of a battery power brick of the battery pack charger system of FIG. **7**.

FIG. **9** is a perspective view of a battery pack charger of the battery pack charger system of FIG. **7**.

FIG. **10** is a perspective view of a battery pack charger system in accordance to another example embodiment.

FIG. **11** is an exploded view of the battery pack charger system of FIG. **10**.

FIGS. **12**A and **12**B are perspective views of an exemplary embodiment of a support of the battery pack charger system of FIG. **10**.

FIG. **13** is a schematic block diagram of a battery pack charger system according to at least one example embodiment.

FIGS. **14** and **15** are schematic block diagrams of controllers according to at least one example embodiment.

FIG. **16** is a flowchart of a method according to example embodiments.

DETAILED DESCRIPTION

Example embodiments relate to a battery pack charger system including a first charger configured to charge a first battery pack, a second charger configured to charge a second battery pack, and a support arranged between the first charger and the second charger. The first charger may be attached on a first side of the support and the second charger may be attached on a second side of the support that is opposite the first side of the support. In one implementation, the first charger and the second charger may be configured directly opposite of each other. This permits a user to charge more than one battery pack at a time while saving space and charging time.

The battery pack charger system includes one power cord to charge multiple, removable battery packs. For example, the power cord may be attached to a primary (first) charger to deliver power and charge the first battery pack, and to a secondary (second) charger to charge a second battery pack. Power may be delivered to the primary charger and then to the secondary charger. Alternatively, power may be delivered to the primary charger and the secondary charger simultaneously. The charging energy may be used to charge the multiple, removable battery packs, which may be used to provide power to various cordless equipment. For example, the removable battery packs may be used to provide power to cordless power tools, cordless lawn tools, cordless radios, etc. The battery pack may be implemented to connect to various different equipment such that the same battery pack may be used on different equipment (e.g., the same battery pack may be used on various different equipment having similar connecting structure with the battery pack.

FIG. **1** is a perspective view of a battery pack charger system **10** in accordance to an example embodiment. Referring to FIG. **1**, the battery pack charger system **10** includes a first charger **100** for charging a removable first battery pack **300***a*, a second charger **200** for charging a removable second battery pack **300***b*, and a support **150** arranged between the first charger **100** and the second charger **200** to separate the first battery pack **300***a* and the second battery pack **300***b*.

The first and second battery packs **300***a*, **300***b* are arranged directly opposite of each other (since the respective charging ports of chargers **100**, **200** are arranged directly opposite of each other). In other words, the first and second battery packs **300***a*, **300***b* directly face each other. To describe in another manner, a side of the first battery pack **300***a* employing terminal slots for receiving terminal blades and a side of the second battery pack **300***b* employing terminal slots for receiving terminal blades are arranged to face each other (i.e., directly opposite of each other). This configuration permits a user to charge more than one battery pack at a time while saving space and time for charging. In addition, the first battery pack **300***a* and the second battery pack **300***b* are oriented such that the first battery pack **300***a* and the second battery pack **300***b* do not interfere or otherwise contact each other during a charging stage of the batteries.

In some implementations, the battery packs **300***a*, **300***b* may be a slide-on style battery pack and may have a voltage ranging from 9 volts to 24 volts, for example. In some implementations, the battery packs **300***a*, **300***b* may have the same number of battery cells and store similar energy. For example, the battery packs **300***a*, **300***b* may include ten battery cells that can store about 55 Watt-hours of energy. In other implementations, the battery packs **300***a*, **300***b* may be compact battery packs having half the number of battery cells. For example, the battery packs **300***a*, **300***b* may include five battery cells that can store about 27 Watt-hours of energy. In still other implementations, the battery packs **300***a*, **300***b* may have different number of battery cells and stored energy. For example, the first battery pack **300***a* may include ten battery cells that can store about 55 Watt-hours of energy, and the second battery pack **300***b* may include five battery cells that can store about 27 Watt-hours of energy.

In some implementations, the battery packs **300***a*, **300***b* may include high energy cells capable of storing about 72 Watt-hours to deliver power for longer period of time. In some implementations, the first battery pack **300***a* and the second battery pack **300***b* may include any combination of cells. In addition, the battery pack charger system **10** may support any combination of compact, standard, or high energy battery packs.

The illustrated battery pack charger system **10** may be configured to charge any of a plurality of different types of battery packs. For example, the battery pack charger system **10** may be capable of charging battery packs **300***a*, **300***b* having nickel-metal hydride ("NiMH"), nickel-cadmium ("NiCad"), lithium-cobalt ("Li—Co"), lithium-manganese ("Li-Ion"), Li—Mn spinel, or other suitable lithium or lithium-based chemistries. In some implementations, the battery pack charger system **10** may make a determination of the type of battery pack inserted into the charger **100** and/or **200** based on, for example, a terminal voltage. In other implementations, the charger **100** and/or **200** may receive information or a signal from the battery pack **300***a* or **300***b* which indicates a battery pack type.

The battery pack charger system **10** may also be configured to receive and charge battery packs **300***a*, **300***b* having any number of different voltage ratings, capacity ratings, configurations, shapes, and sizes. For example, the battery charger **10** may be operable to charge battery packs **300***a*, **300***b* having voltage ratings of 4V, 8V, 12V, 14.4V, 16V, 18V, 20V, 24V, 48V, etc., or battery packs having any voltage rating therebetween. The battery charger system **10** may also be operable to charge battery packs **300***a*, **300***b* having individual cells with capacity ratings of 1.2 Ah, 1.3 Ah, 1.4 Ah, 2.0 Ah, 2.4 Ah, 2.6 Ah, 3.0 Ah, etc. The individual cell capacity ratings are combined to produce a total battery pack capacity rating, which is based both on the capacity ratings of the individual cells, the number of cells in each battery pack **300***a*, **300***b* and the manner in which the cells are connected to each other.

It should be appreciated that in the exemplary embodiment described with respect to FIG. **1** the battery packs **300***a*, **300***b* are the same (or substantially identical) and therefore, the components and/or elements described for the first battery pack **300***a* may be used to describe the second battery pack **300***b*, and vice versa.

Referring to FIG. **2**, the battery packs **300***a*, **300***b* include a housing assembly **310** to substantially enclose a plurality of battery cells (not shown). The housing assembly **310** may include a top housing **320** and a bottom housing **322**. In some implementations, the top and bottom housings **320**, **322** may be molded and/or otherwise formed from a polymeric material, for example. In some implementations, the top and bottom housings **320**, **322** may be joined together by a snap-fit, press-fit, one or more fasteners and/or any other suitable joining method. For example, as shown in FIG. **3**, the top and bottom housings **320**, **322** may be attached via a plurality of screws **366** inserted into corresponding screw bosses **368**. The top and bottom housings **320**, **322** may cooperate to substantially enclose the plurality of battery cells and other components (e.g., a cradle, a circuit board(s), etc.) inside of the battery packs **300***a*, **300***b*.

The top housing **320** may include a base portion **324** and an upper portion **326** that slidably engage with the battery charger **100** or **200**. The base portion **324** may include a first end (i.e., rearward) **328** and a second end (i.e., forward) **330**, and a first guide aperture **332** and a second guide aperture **334** disposed proximate the first end **328**. The upper portion **326** may extend from the base portion **324** and may include a first end **336** and a second end **338**. The first and second guide apertures **332**, **334** may be disposed between the first end **328** of the base portion **324** and the first end **336** of the upper portion **326**. The first end **336** of the upper portion **326** may include a plurality of terminal slots **340**. A terminal block (not shown) is provided inside of the upper portion **326**, for receiving a corresponding plurality of blade terminals **122** (as shown in FIG. **4**) of the battery pack charger **100** or **200**. The plurality of terminal slots **340** ensure a proper, alignment therein of the plurality of blade terminals **122** of the battery pack charger **100** or **200**, and prevent entry of any bent or damaged blade terminals **122** from engaging the battery pack terminal block.

The upper portion **326** may also include a first pair of guide rails **342** and a second pair of guide rails **344** to correspondingly engage with guide rails of the battery charger **100** or **200**, and may slidably engage the first and second pairs of guide rails **342**, **344** to attach the battery pack **300***a* or **300***b* to the battery charger **100** or **200**. In some implementations, leading ends of the first and second pairs of guide rails **342**, **344** may be chamfered or beveled to allow for easier alignment and interconnection between the charger **100** or **200** and/or the battery pack **300***a* or **300***b*.

The second end **338** of the upper portion **326** may be generally aligned with the second end **330** of the base portion **324** and may include an opening **346** through which a latch **348** extends. The latch **348** may be a part of a release mechanism for releasing the battery pack **300***a* or **300***b* from engagement with the battery charger **100** or **200**.

The base portion **324** may include a first guide member **354** and a second guide member **356**. The first and second guide members **354**, **356** may protrude through the guide apertures **332**, **334** of the top housing **320** and extend upward from a surface of base portion **324** when the battery pack **300***a* or **300***b* is in a fully assembled state. The first and second guide members **354**, **356** may be provided to restrict or prevent the battery pack **300***a*, **300***b* from being engaged with a charger that is incompatible with the battery pack **300***a*, **300***b*. That is, a charger that is intended to operate with a battery pack of a different voltage, type and/or configuration may include structure that would interfere with the first and second guide members **354**, **356** to prevent engagement therewith. It will be appreciated from the present disclosure that the first and second guide members **354**, **356** could include any suitable shape and/or configuration.

In some implementations, leading ends of the first and second guide members **354**, **356** may be chamfered or beveled to allow for easier alignment and interconnection between the battery charger **100** or **200** and/or the battery pack **300***a* or **300***b*.

Referring to FIG. **3**, a bottom surface (at the first end **328**) of the bottom housing **322** may include vent openings **361** to remove heat contained in the battery pack **300***a*, **300***b*. In some implementations, the vent openings **361** may also be formed in the bottom surface at the second end **330** of the bottom housing **322**.

At a same side of the first end **328** of battery pack **300***a*, an electrical cord **425** may be attached to a rearward side **107** of the first charger **100** to provide AC electricity (for example, 120 V) to the battery charger **100** and/or battery charger **200**. In some implementations, the rearward side **107** of the first charger **100** may include an extension part **181** such that the electrical cord **425** may extend out therefrom. The extension part **181** supports the electrical cord **425** and serves to prevent the electrical cord **425** from separating out from the first charger **100**.

In some implementations, the electrical cord **425** may be provided on the second charger **200** (instead of on the first charger **100**). In other words, there is only one electrical cord provided in the battery pack charger system **10**. Even though only one electrical cord **425** may be provided, power is delivered to the first charger **100** and/or the second charger **100**, as required. Hence, only a single electrical outlet is required to deliver power to both the first charger **100** and/or second charger **200**. This ensures that less equipment is needed to carry around the battery pack charger system **10**, saves storage space, and/or provides a compact design.

FIG. **4** is a perspective view of the chargers **100** and **200** of the battery pack charger system **10** of FIG. **1**. It should be appreciated that the chargers **100** and **200** of the battery pack charger system **10** are the same (or substantially identical) and therefore, the description of the components and/or elements of the first charger **100** may be used to describe the second charger **200**, and vice versa.

Referring to FIG. **4**, the charger **100** includes a housing **110** having a charging port **115** for receiving and charging the battery pack **300***a* or **300***b*. The housing **110** may be generally composed of plastic material, such as, for example polyethylene, polypropylene, and/or polyurethane, and may enclose components of the battery charger **100** or **200**. In some implementations, the housing **110** may house at least a charging circuit **132** (or **232**) (shown in FIG. **5**) and a plurality of terminal blades **122**.

The housing **110** may include a plurality of openings **142** through which the plurality of terminal blades **122** extend from within the housing **110**. The plurality of openings **142** should have substantially identical shape as the plurality of terminal blades **122**. The plurality of terminal blades **122** may be electrically coupled to the charging circuit **132** or **232** to charge the battery pack **300***a* or **300***b* when the battery pack **300***a* or **300***b* is connected to the charging port **115**. The plurality of terminal blades **122** can also communicate with the battery pack **300***a*, **300***b* to determine at least one of the following functions, such as, for example, detection of the battery packs **300***a*, **300***b*, voltage of the battery packs **300***a*,

300b, temperature of the battery packs **300**a, **300**b, and/or if the battery packs **300**a, **300**b is/are experiencing a fault. In some implementations, two of the blade terminals may be used as positive and negative charging terminals, one blade terminal may be used for data (low current or low voltage), and one blade terminal may be used for battery pack identification. For example, terminal blade **122**a may be a positive power terminal (CH+), terminal blade **122**b may be a negative power terminal (CH−), terminal blade **122**c may be used to monitor current, voltage, and/or temperature of the battery cells and/or the battery packs **300**a or **300**b, and terminal blade **122**d may be used to identify faults or errors in battery packs **300**a or **300**b.

In some implementations, besides having four terminal blades, there may be more or fewer terminal blades while communicating the same operations and/or functions. For example, instead of the four terminal blade arrangement, the housing **110** may house two terminal blades up to six terminal blades.

The housing **110** may include a connecting structure **136** to engage with the battery pack **300**a or **300**b. In some implementations, the connection structure **136** may be two spaced apart, parallel guide rails **138**. The guide rails **138** may be integrally molded with the housing **110** and may be configured to receive the corresponding first and second pairs of guide rails **342**, **344** of the battery pack **300**a or **300**b. For example, the guide rails **138** may slide to the outside of the first and second pairs of guide rails **342**, **344**. In other words, the first and second pairs of guide rails **342**, **344** on the battery pack **300**a or **300**b creates slots to receive the guide rails **138** of the housing **110**. The slots may be typically defined by the respective rails. Furthermore, the guide rails **138** may also initially be configured to receive the corresponding first and second guide members **354**, **356** on the base portion **324** of the battery pack **300**a or **300**b. In other words, the battery pack **300**a or **300**b is inserted into the charging port **115** in two stages. In a first stage, the guide rails **138** loosely receive the first and second guide members **354**, **356** of the battery pack **300**a or **300**b. This avoids a battery pack having a different connection structure from engaging with the guide rails **138**. In a second stage, which occurs during approximately the latter portion of travel of the battery pack **300**a or **300**b relative to the charger housing **110**, the guide rails **138** receive the first and second pairs of guide rails **342**, **344** of the battery pack **300**a or **300**b. This permits the housing **110** and the battery pack **300**a or **300**b to be in a tight fit. In addition, this engagement precisely aligns the plurality of terminal blades **122** with the corresponding plurality of terminal slots **340** of the battery pack **300**a or **300**b.

FIG. **5** is an exploded view of the battery pack charger system **10** of FIG. **1**. Referring to FIG. **5**, the first charger **100** and the second charger **200** are arranged directly opposite of each other (i.e., back-to-back). Because the first charger **100** and the second charger **200** are arranged in this manner, the first and second battery packs **300**a, **300**b are also arranged opposing each other (i.e., face-to-face). The support **150** may be arranged between the first charger **100** and the second charger **200** to separate both of the chargers **100**, **200** and/or the battery packs **300**a, **300**b.

A size/dimension of the support **150** should be sufficient to separate the first battery pack **300**a and the second battery pack **300**b supported by at least the respective upper portions **326** of the battery packs **300**a, **300**b and ensure that the first and second battery packs **300**a, **300**b do not interfere with each other during the charging stage.

In some implementations, a battery pack (**300**a or **300**b) having a single string of 5 cells may have an overall length of approximately 11.5 cm, an overall width of approximately 7.8 cm, and an overall height of approximately 4.5 cm. In some implementations, a battery pack having two strings of 5 cells, wherein the two strings may be connected in parallel or series (not shown), may have an overall length of approximately 11.5 cm, an overall width of approximately 7.8 cm, and an overall height of approximately 6.5 cm. In some implementations, a battery pack having three strings of 5 cells, wherein the three strings may be connected in parallel or series (not shown), may have an overall length of approximately 11.5 cm, an overall width of approximately 7.8 cm, and an overall height of approximately 8.5 cm.

In some implementations, the overall height of the support **150** should be sufficient so that the two battery packs **300**a and **300**b do not interfere (or contact) each other during charging. For example, the support **150** may have an overall length of approximately 9.6 cm, an overall width of approximately 7.2 cm, and an overall height of approximately 2.6 cm. It should appreciated that other size/dimensions of the battery pack(s) may be implemented, depending on the desired voltage ratings, capacity ratings, number of cell, etc.

Referring to FIG. **6**A, the support **150** may include a platform **155** and a projecting part **170**. In an exemplary embodiment as illustrated, the platform **155** may have a substantially semi-circular shape at a rearward side **158** of the platform **155**. It should be appreciated that other shapes of the rearward side **158** of the platform **155** may be employed. For example, the rearward side **158** may be substantially linear (i.e., straight). The shape of the rearward side **158** of the platform **155** should correspond to a shape of the rearward side **107** (shown in FIG. **5**) of the first and second chargers **100**, **200**.

A first extension part **167** is on one side of the rearward side **158** of the platform **155** so that the power cord **425** may extend out from the housing **110** of the charger **100** (or **200**). The first extension part **167** may also be used as a support to prevent the power cord **425** from twisting which may cause possible power shortages. Similarly, the rearward side **107** of the housing **110** of the charger **100** (or **200**) should include the extension part **181** (shown in FIG. **5**) to correspond to the same shape of the rearward side **158** of the support **150** when connected to the structure. At the other side of the rearward side **158** of the platform **155** is a second extension part **169**. The second extension part **169** may be utilized by a user to facilitate holding the support **150**. The second extension part **169** may also provide a stronger support structure (i.e., reduce/distribute stress loads, tension, compression, etc.). In some implementations, the shape and size of the second extension part **169** may match the shape and size of the first extension part **167**. For example, the first and second extension parts **167**, **169** may be a substantially rectangular in shape.

The platform **155** may be used to connect the first charger **100** on one (first) side **157**a and the second charger **200** on the other (second) side **157**b. In one implementation, the charging circuit **132** containing the plurality of terminal blades **122** of the first charger **100** may be attached to the first side **157**a of the platform **155**, and a charging circuit **232** containing a plurality of terminal blades **222** of the second charger **200** may be attached to the second side **157**b of the platform **155**. In order to secure attachment of the charging circuit **132** to the first side **157**a of the platform **155**, a first bracket **164** may be formed on the platform **155**. The first bracket **164**, near the rearward side **158** of the platform, may extend upwardly from a surface of the first side **157***a* of the platform **155**. Near a forward side **165** of the platform **155**, a second bracket **166** may extend upwardly from the surface of the first side **157***a* of the platform **155**. The first and second brackets **164**, **166** may be integrally molded with the first side **157***a* of the platform **155**. The first and second brackets **164**, **166** prevent movement of the charging circuit **132** and/or hold the charging circuit **132** securely in place when the plurality of terminal blades **122** engage the corresponding terminals of the terminal block of the battery pack **300***a*. In some implementations, the first and second brackets **164**, **166** may be substantially parallel with respect to each other. In some implementations, additional bracket(s) may be formed on the first side **157***a* of the platform **155** to securely hold the charging circuit **132** and the terminal blades **122**. For example, there may be (smaller) bracket(s) on each side of the first and second brackets **164**, **166** in a perpendicular direction thereof. The first and second brackets **164**, **166** may be formed on the second side **157***b* of the platform **155**, directly opposite to the first and second brackets **164**, **166** of the first side **157***a*, in a similar manner.

The platform **155** may further include two spaced apart pedestals **161***a*, **161***b* on the first side **157***a* of the platform **155** and two spaced apart pedestals **162***a*, **162***b* on the second side **157***b* of the platform **155**. The pedestals **161***a*, **161***b* may be integrally molded with the first side **157***a* of the platform **155**, and the pedestals **162***a*, **162***b* may be integrally molded with the second side **157***b* of the platform **155**. The pedestals **161***a*, **161***b* may be configured to align the first charger **100**, and the pedestals **162***a*, **162***b* may be configured to align the second charger **200**. In one implementation, the pedestals **161***a*, **161***b* may be inserted into the corresponding screw boss **368** of the first charger **100**. Once the first charger **100** engages with the platform **155**, screws **366** may be used to tightly secure the first charger **100** to the platform **155** of the support **150**. The second charger **200** may be similarly engaged with the platform **155** of the support—yet on the second side **157***b* of the platform **155**.

The platform **155** may include a pair of sidewalls **177** to protect the first and second chargers **100**, **200**. Specifically, the pair of sidewalls **177** may protect the plurality of terminal blades **122** from damage. The height of the sidewalls **177** should be sufficient to cover (extend over) the plurality of terminal blades **122**, but not to extend or hinder the connection of the battery packs **300***a*, **300***b* to their respective battery chargers **100**, **200**.

The projecting part **170** may extend away from the platform **155** and may be integrally molded with the platform **155**. In one implementation, the projecting part **170** may extend in a direction of the battery packs **300***a* or **300***b* in a longitudinal direction. The projecting part **170** should have a length in the longitudinal direction sufficient to support the battery packs **300***a*, **300***b* on each side thereof. For example, one side (first) **173***a* of the projecting part **170** may support and/or contact the upper portion **326** of the first battery pack **330***a* and the other side (second) **173***b* of the projecting part **170** may support and/or contact the upper portion **326** of the second battery pack **330***b*. Further, the projecting part **170** should have sufficient height so that the battery packs **300***a* and **300***b* do not interfere (i.e., contact) with each other during the charging stage. In an exemplary embodiment as illustrated, the projecting part **170** may have an overall dimension of approximately 4.9 cm in length, approximately 4.0 cm in width, and approximately 2.6 cm in height.

Referring to FIG. **6**B, the projecting part **170** may have end portions **179** which may be attached to a surface of the forward side **165** of the platform **155**. In an exemplary embodiment as illustrated, the end portions **179** attached to the forward side **165** of the platform **155** create an inverse C-shape (when viewed from a top view). It should be appreciated that the platform **155** may be created in other shapes. The projecting part **170** may include an opening **175** to facilitate transfer of heat trapped in the battery pack charging system **10**. In addition, the opening **175** reduces cost of material and/or overall weight of the support **150**. Ends **178** of the projection part **170** may be chamfered or beveled to avoid straight edges (e.g., 90 degree edges) which may damage the battery packs **300***a*, **300***b*.

FIG. **6**C is a top view of the support **150** including the platform **155** and the projection part **170** in accordance with another example embodiment. The support **150** of FIG. **6**C is similar to the support **150** of FIG. **6**B except that the opening **175** of the projection part **170** includes reinforcing members **188**. The reinforcing members **188** may produce a stronger support structure to the projecting part **170**. The reinforcing members **188** may be integrally molded with the projecting part **170** and/or to the platform **155**.

In some implementations, the reinforcing members **188** may be several members within the opening **175** of the projecting part **170**. In an exemplary embodiment as illustrated, two horizontal reinforcing members may be within the opening **175** of the projecting part **170**. The horizontal reinforcing members may be evenly spaced within the opening **175**. In another example embodiment, a vertical reinforcing member(s) may be formed within the opening **175** of the projecting part **170**.

FIG. **7** is a perspective view of a battery pack charger system **20** in accordance to another example embodiment. Referring to FIG. **7**, the battery pack charger system **20** may include a first charger **100'** for charging the first battery pack **300***a*, a second charger **200'** for charging the second battery pack **300***b*, a support **150'** arranged between the first charger **100'** and the second charger **200'**, and a battery power brick **500**. It should be appreciated that the battery packs **300***a*, **300***b* are identical to the battery packs as described in FIG. **1**; however the first charger **100'**, the second charger **200'** and the support **150'** of FIG. **7** are not the same respective elements as described in FIG. **1**, and will be discussed further in detail. Further, it should also be appreciated that functions and/or operations of the first and second chargers **100'**, **200'**, the first and second battery packs **300***a*, **300***b*, and the support **150'** are similar to the example embodiment of FIG. **1**, and will not be discussed in detail in this section.

The power brick **500** may facilitate portability of charging the battery packs **300***a*, **300***b* without added internal power components (e.g., transformer, rectifier, filter, regulator circuits, etc.) located in the battery packs **300***a*, **300***b* and/or chargers **100'** or **200'**, and makes it unnecessary to include additional component(s) for use with a specified power source (i.e., the battery packs and/or chargers can be powered from the same power source, for example, 120 V). Hence, removing the added internal power component(s) may reduce weight and size which must be carried by the battery packs **300***a*, **300***b* and/or chargers **100'**, **200'**. Additionally, the presence of the power brick **500** may reduce heat generated within the battery packs **300***a*, **300***b* and/or chargers **100'**, **200'**.

The power brick **500** may include an electrical outlet plug **525** to be plugged into an AC wall outlet to receive power. In some implementations, the electrical outlet plug **525** may be within (i.e., built-in) the power brick **500**. For example, the electrical outlet plug **525** is part of the power brick **500** and extends directly out from the power brick **500**. The power brick **500** may be connected to the first charger **100'** and/or the second charger **200'** via the electrical cord **425**. When the power brick **500** is plugged into the AC wall outlet, the power brick **500** delivers power to the first charger **100'** and/or the second charger **200'** and charges the respective battery packs **300**a, **300**b.

Referring to FIGS. **8**A and **8**B, the power brick **500** may be enclosed within a casing **510** to protect external and/or internal components of the power brick **500**. In some implementations, the casing **510** may be substantially rectangular in shape. In some implementations, the casing **510** may be another shape as long as the casing **510** corresponds to the shape of the power brick **500**. The casing **510** may include a first end **512** and a second end **514**. Each of the first and second ends **512**, **514** of the casing **510**, may include recesses **520**, **522**, respectively, configured to enable wrapping the electrical cord **425** within the recesses **520**, **522**.

Near each corner of the casing **510** there may be included a rod **532** (within the recesses **520**, **522**) to facilitate wrapping the electrical cord **425** around the power brick **500** (as shown in FIG. **8**A). The rods **532** further enable the electrical cord **425** to be wrapped in a tight manner (i.e., wrapping the electrical cord **425** around the casing **510** in a bottom to top arrangement).

Referring back to FIG. **7**, the casing **510** of the power brick **500** may include a pair of guide rails **550** to correspondingly receive the first charger **100'** (when the first battery pack **300**a is removed from the first charger **100'**). Leading ends **566** of the pair of guide rails **550** may be chamfered or beveled to allow for easier alignment and interconnection between the casing **510** of the power brick **500** and the first charger **100'**.

In some implementations, the pair of guide rails **550** may be located at the opposite side with respect to the outlet plug **525** of the power brick **500**. Hence, the casing **510** may include an opening **515** opposite the side of the pair of guide rails **550** to expose the electrical outlet plug **525**. This permits the casing **510** of the power brick **500** to be attached with the first battery charger **100'** (as shown in FIG. **10**), and provide electrical power while the power brick **500** is plugged into the AC wall outlet. While the user operates the cordless device powered by the first battery pack **300**a, the second battery pack **300**b is still being charged via the power brick **500**, thus saving charging time, and due to its compact configuration, saving space.

FIG. **9** is a perspective view of the chargers **100'** and **200'** of the battery pack charger system **20** of FIG. **7**. It should be appreciated that the chargers **100'** and **200'** of battery pack charger system **20** are the same (or substantially identical) and therefore, the description of the components and/or elements of the first charger **100'** may be used to describe the second charger **200'**, and vice versa.

Referring to FIG. **9**, each of the chargers **100'**, **200'** includes a housing **135** for receiving the battery pack **300**a, **300**b and/or the casing **510** of the power brick **500**, and a pair of reinforcing members **250**. The housing **135** and the pair of reinforcing members **250** may be generally composed of plastic material, such as, for example polyethylene, polypropylene, and/or polyurethane, and may be molded together.

Each inside (longitudinal) sidewall of the housing **135** includes a guide rail **141**. The guide rails **141** may be integrally molded with the housing **135** and may be configured to receive the corresponding first and second pairs of guide rails **342**, **344** of the battery pack **300**a or **300**b, and/or the pair of guide rails **550** of the casing **510** of the power brick **500**.

The pair of reinforcing members **250** may be attached at an outside (longitudinal) sidewall of the housing **135**. In some implementations, the pair of reinforcing members **250** extends outwardly from the outside sidewall of the housing **135**. The pair of reinforcing members **250** may provide structural support for the housing **135**. In addition, the pair of reinforcing members **250** may protect the battery packs **300**a, **300**b, and/or the power brick **500**. More specifically, the configuration of the pair of reinforcing members **250** extending out from the housing **135** protects the battery packs **300**a, **300**b, and/or the power brick **500** from damages (i.e., drops, impacts, force, etc.), and hence, provides for a tougher, more protective case. In particular, the pair of reinforcing members **250** may protect a portion of the battery packs **300**a, **300**b and/or the power brick **500** at or near the sidewalls.

At a central portion of each of the reinforcing members **250** includes a securing rib **257** for securing the electrical cord **425**. The securing rib **257** may be integrally molded in the reinforcing member **250** forming a slot to secure the electrical cord **425** against the reinforcement member **250**. For example, when the power brick **500** is disengaged from the first charger **100'** (or the second charger **200'**), the electrical cord **425** may be wrapped around the reinforcing members **250** and snapped into the securing rib **257** to hold the electrical cord **425** in place. In other words, the securing rib **257** allows the electrical cord **425** to be secured and prevents the electrical cord **425** from unraveling after the electrical cord **425** is wrapped around the reinforcement members **250**.

Referring to FIG. **11**, the housing **135** may house at least the charging circuit **132'** (or **232'**) and the plurality of terminal blades **122'** (or **222'**). The housing **135** may further include an opening **373** at a bottom surface of the housing **135** to insert the plurality of terminal blades **122'** (or **222'**) through the opening **373**. In some implementations, the opening **373** may be substantially rectangular in shape. A portion of the charging circuit **132'** (or **232'**) including the plurality of terminal blades **122'** (or **222'**) may be inserted into the opening **373** to provide a charging port when the battery pack **300**a or **300**b is engaged to the housing **100'** or **200'**.

The chargers **100'** and **200'** are connected to the support **150'**. In some implementations, the chargers **100'** and **200'** may be connected to the support **150'** by one or more fasteners. For example, the chargers **100'** and **200'** may be attached via a plurality of screws (not shown) inserted into corresponding screw bosses **368** near each corner of the support **150'**. The screw bosses **368** of the chargers **100'** and **200'** may cooperate with corresponding screw bosses **195** in the support **150'**.

The first charger **100'** and the second charger **200'** may be arranged directly opposite of each other (i.e., back-to-back). Because the first charger **100'** and the second charger **200'** are arranged in this manner, the first and second battery packs **300**a, **300**b are also arranged directly opposite of each other (i.e., face-to-face). The support **150'** may be arranged between the first charger **100'** and the second charger **200'** to separate the battery packs **300**a, **300**b (and/or the power brick **500**). The support **150'** should have a dimension/size to separate the first battery pack **300**a and the second battery pack **300**b (and/or the power brick **500**) from contacting each other (i.e., interfering during the charging stage).

Referring to FIGS. **12**A and **12**B, the support **150'** of the battery pack charger system **20** may include an outer ring portion **184** and an inner ring portion **186**. In an exemplary embodiment as illustrated, the outer ring portion **184** may be substantially rectangular in shape, having a first end **151** and a second end **153**. It should be appreciated that other shapes of the outer ring portion **184** may be employed. The shape of the outer ring portion **184** should correspond to a shape of the housing **135** of the first and second chargers **100'**, **200'**. The outer ring portion **184** and the inner ring portion **186** may be generally composed of plastic material, such as, for example polyethylene, polypropylene, and/or polyurethane, and may be molded together.

The outer ring portion **184** may include the screw bosses **195** at an outer wall of the outer ring portion **184** to correspond and engage with the screw bosses **368** of the first and second chargers **100'**, **200'** (as shown in FIG. **9**), so as to connect the support **150'** with the housing **135** of the first and second chargers **100'**, **200'**. In some implementations, the screw bosses **195** may be near the four corners of the outer ring portion **184**. The screw bosses **195** may be integrally molded to an outer wall of the outer ring portion **184**.

The outer ring portion **184** may include an indicator window **193** (as shown in FIG. **10**) at each sidewall of the outer ring portion **184** to display the status of the battery packs **300***a*, **300***b*. The indicator window **193** may be inserted into an insertion portion **191** formed in the outer ring portion **184**. The insertion portion **191** may be integrally formed along a sidewall of the outer ring portion **184**. In some implementations, the indicator window **193** may be triangular in shape which matches the shape of the insertion portion **191**. It should be appreciated that other shapes may be employed as long as the insertion portion **191** and the indicator window **193** have the same shape. The insertion portion **191** may include an opening **197** to permit light to pass through and display the status of the battery packs **300***a* and **300***b*. In some implementations, the indicator window **193** may indicate a steady-state or a blinking state indicating the status of the battery packs **300***a* and **300***b* connected to the respective charging ports. For example, a non-blinking (steady-state) light may indicate that the battery pack **300***a* or **300***b* is fully charged, and a blinking light may indicate that the battery pack **300***a* or **300***b* is not fully charged but still charging. In some implementations, the indicator window **193** may be colored to indicate the status.

In some implementations, light emitting diodes (LEDs) may be employed that may be electrically coupled to the respective charging circuit **132'**, **232'**. The LEDs may indicate the status of the respective battery packs **300***a*, **300***b* and may be displayed through the indicator window **193**. In some implementations, there may be two LEDs associated with the respective charging port. For example, one of the LEDs may be one color (e.g., green), while the other LED may be a different color (e.g., red). In some implementations, when charging the battery packs, the LEDs may illuminate to indicate the status of the battery packs **300***a*, **300***b*. For example, a continuous red light may indicate that the battery packs **300***a*, **300***b* may be charging, a continuous green light may indicate that charging is complete, and blinking red (or green) lights may indicate an error or fault with the battery packs **300***a*, **300***b*.

The inner ring portion **186** may be located at the second end **153** of the outer ring portion **184**, for example. The inner ring portion **186** creates an opening to allow the latch **348** (as shown in FIG. **10**) of the battery pack **300***a* or **300***b* to be inserted therethrough and securely hold the battery pack **300***a* or **300***b* in the charger **100'** or **200'**. Similarly, at a corresponding location of the inner ring portion **186**, the housing **135** of the first and second chargers **100'**, **200'** may include an opening **182** to allow the latch **348** to extend into the opening **182** and the opening of the inner ring portion **186** to securely hold the battery pack **300***a* or **300***b*.

FIG. **13** is a schematic block diagram of the battery pack charger system **10** according to at least one example embodiment. As shown in FIG. **13**, the battery pack charger system **10** may include the first charger **100** and the second charger **200**. The first charger **100** and the second charger **200** may be communicatively coupled via a wire **715**. The first charger **100** may include a power module **705**, an interface **710**, a charging module **720**, a controller (control circuit) **725**, and a power cord **425**. The second charger **200** may include an interface **730**, a charging module **740**, and a controller (control circuit) **750**.

In some implementations, the wire **715** may be communicatively coupled to (e.g., between) the interface **710** and the interface **730**. In some implementations, the wire **715** may be configured to transfer power from the first charger **100** to the second charger **200** and/or configured to carry communication signals between the first charger **100** and the second charger **200**. For example, the communication signals may include information or data associated with powering the chargers **100** or **200**, a detection of the battery packs **300***a* or **300***b*, a status of the battery pack **300***a* or **300***b* and/or battery charge. The data associated with powering the chargers **100** and/or **200** may include an amount of power to power a processor, a memory, and the like. The data associated with detection may include the detection of the battery packs **300***a* or **300***b* in the respective chargers **100** or **200**, and the like. The status of the battery pack **300***a* or **300***b* and/or battery charge may include a battery capacity, a charge amount, a charging power, a voltage, a current, a temperature, a charging status (e.g., full/charging), an error(s) associated with charging the battery pack **300***a* or **300***b* and/or the like.

The power module **705** may be configured to convert AC (e.g., 120 V) to DC (e.g., 20 V) and transform a voltage associated with a wall outlet to a voltage associated with a cordless device. Converting AC to DC and transforming the voltage associated with the wall outlet may include use of a transformer. The voltage can be a varying voltage (e.g., between 5V and 20V and the like). The power module **705** may be configured to communicate conditions or status associated with power to the controller **725**. For example, the power module **705** may communicate at least one voltage, at least one current and/or at least one power. For example, a voltage associated with the wall outlet, a converted voltage, and/or a current drawn may be communicated. The power module **705** may be configured to transfer DC power to the interface **710**. The interface **710** may be configured to couple DC power from the first charger **100** to the interface **730** of the second charger **200** (e.g., via the wire **715**).

The interface **730** may be configured to receive communications from the first charger **100** via the wire **715**. The interface **730** may be configured to communicate the communications to the controller **750**. The interface **730** may be configured to receive DC power from the interface **710** of the first charger **100**.

The controller **725** may be configured to receive information or data associated with detection of the first battery pack **300***a*, receiving power associated with the first charger **100** and a status and/or charge of the first battery pack **300***a*. The information or data relating to detection can include an identification of battery (i.e., type of battery) and/or detection of battery in the charging port **115** of the first charger **100**.

The information or data relating to power can include a desired voltage, current and/or power setting, an over temperature protection threshold, an over voltage protection threshold, an over current protection threshold, a communication time interval and/or the like. The information or data relating to the status and/or charge of the first battery pack **300***a* charge may include a battery capacity, a charge amount, a charging power, a voltage, a current, a temperature, a charging status (e.g., full/charging), an error(s) associated with charging the first battery pack **300***a* and/or the like. The controller **725** may be configured to use the desired voltage, current and/or power setting, the over temperature protection threshold, the over voltage protection threshold, the over current protection threshold, the communication time interval and/or the like to modify voltage, current and/or power settings of the first charger **100**. The controller **725** may be configured to use the status of and/or charge of the first battery pack **300***a* to modify voltage, current and/or power settings of the first charger **100** that are associated with the powering the first charger **100** and/or charging the first battery pack **300***a*.

In some implementations, the controller **725** may be configured to generate signals to protect the first charger **100** should an error (e.g., over current and/or high temperature) be indicated by the status and/or charge of the first battery pack **300***a*. For example, the controller **725** may be configured to disconnect or cause the first charger **100** to stop (or reduce) transferring DC power should an error condition be indicated by the status and/or charge of the first battery pack **300***a*. The controller **725** may be configured to disconnect or cause the first charger **100** to stop transferring DC power should a fully charged condition be indicated by the status and/or charge of the first battery pack **300***a*.

In some implementations, the controller **725** may be configured to receive signals from the power module **705**. The signals may indicate at least one of a power, a voltage and a current associated with the power module **705** (and, therefore, the first charger **100**). The controller **725** may be configured to disconnect or cause the power module **705** to stop (or reduce) transferring DC power should at least one of the power, the voltage and the current associated with the power module **705** exceed a threshold value. The controller **725** may be configured to disconnect or cause the power module **705** to stop (or reduce) transferring DC power should other signals associated with the first charger **100** indicate a parameter exceeds a threshold value.

The charging module **720** may be configured to charge the first battery pack **300***a* using power received from the power module **705**. The charging module **720** may be configured to monitor a status of the first battery pack **300***a*. For example, the charging module **720** may measure a voltage, a current, a temperature and the like of the first battery pack **300***a*. The charging module **720** may be configured to monitor a charging status of the first battery pack **300***a*. For example, the charging module **720** may monitor whether or not the first battery pack **300***a* is fully charged or charging, an error associated with charging the first battery pack **300***a* and/or the like.

In some implementations, once the charging module **720** determines that the first battery pack **300***a* is fully charged, the controller **725** may direct power to charge the second battery pack **300***b*. In other words, the controller **725** may be configured to sequentially charge the first battery pack **300***a* and then the second battery pack **300***b*. In some implementations, the controller **725** may direct the charging modules **720** and **740** to supply a charge to both of the battery packs **300***a* and **300***b*. In other words, controller **725** may be configured to simultaneously charge the first battery pack **300***a* and the second battery pack **300***b* together.

The interface **710** may be configured to communicate with the interface **730** of the second charger **200** in order to facilitate communications between the first charger **100** and the second charger **200**. The interface **730** may be configured to send communications from the second charger **200** to the interface **710** via the wire **715**. The interface **730** may be configured to communicate the communications to the controller **750**. The interface **730** may be configured as a conduit for receiving DC power from the first charger **100** via the wire **715** in order to charge the second battery pack **300***b*.

The controller **750** may be configured to communicate a detection of the second battery pack **300***b*, a desired voltage, current and/or power setting, an over temperature protection threshold, an over voltage protection threshold, an over current protection threshold, a communication time interval and/or the like. The desired voltage, current and/or power setting may be based on an amount of power desired to charge the second battery pack **300***b* and/or provide power to the second charger **200** (e.g., to power a processor, a memory, and the like). In some implementations, the controller **750** may be configured to negotiate with the first charger **100** based on a desired voltage, current and/or power setting. The desired voltage, current and/or power setting may include at least one of a power, a voltage, and/or a current.

In some implementations, the controller **750** may be configured to generate signals to protect the second charger **200** should an error (e.g., over current and/or high temperature) be indicated by the status and/or charge of the second battery pack **300***b*. For example, the controller **750** may be configured to disconnect or cause the second charger **200** to stop (or reduce) transferring DC power should an error condition be indicated by the status and/or charge of the second battery pack **300***b*. The controller **750** may be configured to disconnect or cause the second charger **200** to stop transferring DC power should a fully charged condition be indicated by the status and/or charge of the second battery pack **300***b*.

The controller **750** may be configured to receive signals from the charging module **740**. The signals may indicate at least one of a power, a voltage and a current associated with the charging module **740** (and, therefore, the second battery pack **300***b*). The controller **750** may be configured to disconnect or cause the charging module **740** to stop (or reduce) charging the second battery pack **300***b* once the second battery pack **300***b* is fully charged.

In some implementations, the controller **750** may be configured to communicate a signal(s) to the first charger **100** indicating the error condition(s) exist via the wire **715** and the interface **730**. The controller **750** may be configured to send a signal(s) to the first charger **100** indicating an error condition(s) exist (at the second charger **200**) to stop (or reduce) transferring DC power via the wire **715** and the interface **710**. In other words, the controller **750** may be configured to send a signal(s) to the power module **705** in the first charger **100** to stop (or reduce) directing power to the second charger **200** should an error condition exist at the second charger **200** as indicated by the received signal.

FIGS. **14** and **15** are schematic block diagrams of the controllers (control circuits) **725** and **750** according to at least one example embodiment. As shown in FIG. **14**, the controller **725** of the first charger **100** includes a power status module **810**, a battery status module **815**, a power control safety module **820**, a power disconnect module **825**, a switch module **730**, a processor **835**, and a memory **840**.

The power status module **810** may be configured to receive information related to the powering of the first charger **100**. For example, the information may include at least one voltage, at least one current and/or at least one power associated with the first charger **100**.

The battery status module **815** may be configured to receive information related to a status of the first battery pack **300***a*. For example, the information related to the status of first battery pack **300***a* may include a battery capacity, a charge amount, a time to full charge, a charging power, a charging status (e.g., full/charging), an error(s) associated with charging the battery and/or the like. In some implementations, the battery status module **815** may generate indicators based on the information related to the status of the first battery pack **300***a*.

The power control safety module **820** may be configured to receive measurable data (e.g., temperature, current, voltage, power) regarding the first charger **100** and/or the first battery pack **300***a* and determine if at least one of the measurable data exceeds a threshold value. If at least one of the measurable data exceeds a threshold value, the power control safety module **820** may be configured to output an error status to, for example, the power disconnect module **825**.

The power disconnect module **825** may be configured to disconnect or cause the power module **705** to stop (or reduce) transferring DC power. For example, the power disconnect module **825** may receive an indicator from at least one of the power control safety module **820** and the power status module **810**. The indicator may indicate a condition that can be corrected by reducing power output to the first charger **100**. Accordingly, the power disconnect module **825** may instruct (e.g., change a setting associated with) the power module **705** to reduce an output power thus, for example, reducing temperature, current and/or voltage. The indicator may indicate a condition that can be corrected by stopping or disconnecting power output to the first charger **100**. Accordingly, the power disconnect module **825** may instruct (e.g., change a setting associated with) the power module **705** to stop outputting power thus, for example, eliminating an over current and/or over voltage condition and/or a high temperature condition.

The switch module **830** may be configured to switch powering to the second charger **100** once the first battery pack **300***a* in the first charger **100** is fully charged. In some implementations, once the battery status module **815** indicates that the first battery pack **300***a* is fully charged, the switch module **830** may direct power to charge the second battery pack **300***b*. In other words, the switch module **830** may be configured to sequentially charge the first battery pack **300***a* and then the second battery pack **300***b*. In some implementations, the switch module **830** may direct the charging modules **720** and **740** to supply a charge to both of the battery packs **300***a* and **300***b*. In other words, switch module **830** may be configured to simultaneously charge the first battery pack **300***a* and the second battery pack **300***b*.

The processor **835** may be configured to execute instructions. For example, processor **835** can be associated with any of the components of the controller **725**, and can be used for execution of any of the operations of the controller **725**. The memory **840** may be configured to store instructions (e.g., as code segments) and/or data associated with implementing functions associated with the controller **725** and/or the first charger **100**. In some implementations, the memory **840** may store threshold values to operate the power control safety module **820**. For example, the threshold values may include an over temperature protection threshold, an over voltage protection threshold, an over current protection threshold and/or the like. In some implementations, the threshold values may include default threshold values and a protection value of the first battery pack **300***a*. For example, the power control safety module **820** may be configured to read and use the protection value(s) of the first battery pack **300***a*. In some implementations, the threshold values may include resetting the protection value(s) of the first charger **100** to the default threshold values. For example, the power control safety module **820** may be configured to reset the protection value(s) of the first charger **100** to the default threshold values. For another example, the power control safety module **820** may be configured to reset the protection value(s) of the first charger **100** to the default threshold values upon determining the first battery pack **300***b* has been disconnected from the first charger **100**. In some implementations, the memory **840** may store battery historical charge and/or recondition/recalibration data.

As shown in FIG. **15**, the controller **750** of the second charger **200** includes a battery status module **915**, a power control safety module **920**, a charge disconnect module **925**, a processor **935**, and a memory **940**. The battery status module **915** may be configured to determine information related to the status and/or charge status of the second battery pack **300***b*. The information related to the status and/or charge status of second battery pack **300***b* may include a battery capacity, a charge amount, a time to full charge, a charging power, a charging status (e.g., full/charging), an error(s) associated with charging the battery and/or the like. The battery status module **915** may generate indicators based on the information related to the status and/or charge status of the second battery pack **300***b*. In some implementations, the indicators may be subsequently communicated to the first charger **100**.

In some implementations, the battery status module **915** may be configured to calculate a value. For example, the battery status module **915** may calculate a battery capacity percentage based on a charge amount and a battery capacity.

The power control safety module **920** may be configured to receive measurable data (e.g., temperature, current, voltage, power) regarding the second charger **200** and/or the second battery pack **300***b* and determine if at least one of the measurable data exceeds a threshold value. If at least one of the measurable data exceeds a threshold value, the power control safety module **920** may be configured to output an error status to, for example, the power disconnect module **925**. If at least one of the measurable data exceeds a threshold value, the power control safety module **920** may be configured to output an error status for communication to, for example, the first charger **100** via interface **630**.

The power disconnect module **925** may be configured to disconnect or cause the battery status module **915** to stop (or reduce) charging of the second battery pack **300***b*. For example, the power disconnect module **925** may receive a signal from at least one of the power control safety module **920** and the battery status module **915**. The signal may indicate a condition that can be corrected by reducing power to the second battery pack **300***b*. Accordingly, the power disconnect module **925** may instruct (e.g., change a setting associated with) the charging module **640** to reduce an output power thus, for example, reducing temperature, current and/or voltage of, for example, the second battery pack **300***b*. The signal may indicate a condition that can be corrected by stopping or disconnecting the second battery pack **300***b* from a charge (e.g., charge voltage). Accordingly, the power disconnect module **925** may instruct (e.g., change a setting associated with) the charging module **640** to stop outputting power thus, for example, eliminating an over current and/or over voltage condition and/or a high temperature condition.

The processor **935** may be configured to execute instructions. For example, the processor **935** can be associated with any of the components of the controller **750**, and can be used for execution of any of the operations of the controller **750**. The memory **940** may be configured to store instructions (e.g., as code segments) and/or data associated with implementing functions associated with the controller **750** and/or the second charger **200**. In some implementations, the memory **940** may store threshold values to operate the power control safety module **920**. For example, the threshold values may include an over temperature protection threshold, an over voltage protection threshold, an over current protection threshold and/or the like. In some implementations, the threshold values may include default threshold values and a protection value of the second battery pack **300***b*. For example, the power control safety module **920** may be configured to read and use the protection value(s) of the second battery pack **300***b*. In some implementations, the threshold values may include resetting the protection value (s) of the second charger **200** to the default threshold values. For example, the power control safety module **920** may be configured to reset the protection value(s) of the second charger **200** to the default threshold values. In another example, the power control safety module **920** may be configured to reset the protection value(s) of the second charger **200** to the default threshold values upon determining the second battery pack **300***b* has been disconnected from the second charger **200**. In some implementations, the memory **940** may store battery historical charge and/or recondition/recalibration data.

As may be appreciated, the processor (or at least one processor) **835** and/or **935** may be formed on a substrate and may be utilized to execute instructions stored on the memory (or at least one memory) **840** and/or **940**, so as to thereby implement the various features and functions described herein, or additional or alternative features and functions. Of course, the processor **835** and/or **935** and the memory **840** and/or **940** may be utilized for various other purposes. In particular, it may be appreciated that the memory **840** and/or **940** may be understood to represent an example of various types of memory and related hardware and software which might be used to implement any one of the modules described herein. Systems and/or methods described above and/or below may include data and/or storage elements. The data and/or storage elements (e.g., data base tables) may be stored in, for example, the memory **840** and/or **940**.

The memory **840** and/or **940** may store information within the first charger **100** and/or the second charger **200**. In one implementation, the memory **840** and/or **940** may be a volatile memory unit or units. In another implementation, the memory **840** and/or **940** may be a non-volatile memory unit or units. The memory **840** and/or **940** may also be another form of computer-readable medium, such as a magnetic or optical disk. The memory **840** and/or **940** may be a non-transitory computer readable medium.

FIG. **16** is a flowchart of a method according to example embodiments. The steps described with regard to FIG. **10** may be performed due to the execution of software code stored in a memory (e.g., at least one memory **840** and/or **940**) associated with the first charger **100** and/or the second charger **200** and executed by at least one processor (e.g., at least one processor **835** and/or **935**) associated with the first charger **100** and the second charger **200**. However, alternative embodiments are contemplated such as a system embodied as a special purpose processor. Although the steps described below are described as being executed by a processor, the steps are not necessarily executed by a same processor. In other words, at least one processor may execute the steps described below with regard to FIG. **10**.

As shown in FIG. **16**, in step S**1005** the first battery pack **300***a* is inserted into the first charger **100** to establish a communication link between the first battery pack **300***a* and the first charger **100**. For example, the communication link may be associated with power, detection of battery, battery capacity, charge amount, time to full charge, charging power, charging status (e.g., full/charging), error(s) associated with charging the battery and/or the like.

In step S**1010** power is delivered to and received by the first charger **100** (i.e., regulate power from a power source and distributing power from the power source to other components or modules within the first charger **100**). In some implementations, at least one voltage, at least one current and/or at least one power associated with the first charger **100** (and/or first battery pack **300***a*) may be received by the first charger **100**. For example, a voltage associated with the wall outlet, a converted voltage, and/or a current drawn may be communicated.

In step S**1015** a charge amount of the first battery pack **300***a* may be determined to determine whether the first battery pack **300***a* requires a charge or not. In some implementations, the first charger **100** may charge the inserted first battery pack **300***a* with a constant charging current of 2 A, for example, until the first battery pack **300***a* is nearly fully charged. The charging current may be gradually tapered off (e.g., in a linear manner) to simulate a constant voltage charging mode. In other implementations, the charging currents generated by the first charger **100** may be in the range of approximately 0.1 A to approximately 5.0 A, although charging currents outside of this range may also be suitable.

In some implementations, step S**1015** may be commencing while charging the second battery pack **300***a* in step S**1035**. In other words, steps S**1015** and S**1035** may be commencing simultaneously. Accordingly, both battery packs **300***a* and **300***b* may be charging at the same time.

Once the first battery pack **300***a* is fully charged at step S**1020**, the controller determines, at step S**1025** whether there is a second battery pack **300***b* inserted into a second charger **200**. If there is not a second battery pack **300***b* inserted into a second charger **200**, the controller ends the process. If there is a second battery pack **300***b* inserted into a second charger **200**, the controller proceeds to step S**1030**.

In step S**1030**, power is received and delivered to the second charger **200** via the first charger **100**. Since power is only delivered to the first charger **100**, the second charger **200** may receive power via the first charger **100**.

In some implementations, the power may be delivered in a reverse direction (i.e., second charger **200** to first charger **100**). That is, the power cord **425** may be connected to the second charger **200**. For example, the power may be delivered to the second charger **200** (i.e., regulate power from a power source and distributing power from the power source to other components or modules within the second charger **200**) and then deliver the power to the first charger **100**. In other words, the first charger **100** receives power via the second charger **200**.

In step S**1035** a charge amount of the second battery pack **300***b* may be determined to determine whether the second battery pack **300***b* requires a charge or not. In some implementations, the second charger **200** may charge the second battery pack **300***b* (inserted in the second charger **200**) with a constant charging current of 2 A, for example, until the second battery pack **300***b* is nearly fully charged. The charging current may be gradually tapered off (e.g., in a linear manner) to simulate a constant voltage charging mode. In other implementations, the charging currents generated by the second charger **200** may be in the range of 0.1 A to 5.0 A, although charging currents outside of this range may also be suitable.

In step S**1040**, once the second battery pack **300***b* is fully charged, the controller ends the process.

In some implementations, the charging of the first and second battery packs **300***a*, **300***b* may be performed simultaneously when both battery packs are inserted in their respective chargers **100**, **200**.

Example embodiments relate to a battery pack charger system designed to accommodate a slide-on style battery pack. While exemplary embodiments illustrated herein describe accommodating a slide-on style battery pack, the battery pack charger system may be used to charge other types of battery packs. For example, the battery pack charger system may charge a tower type battery packs. In some implementations, the battery pack charger system may charge different types of battery packs. For example, the one charger may charge a slide-on style battery pack and the other charger may charger a tower type battery pack.

The configurations, shapes, and sizes of the battery packs include but are not limited to configurations, shapes, and sizes of battery packs that are attachable to and detachable from electrical devices such as power tools, test and measurement equipment, vacuum cleaners, outdoor power equipment, and vehicles. Power tools include, for example, drills, circular saws, jigsaws, band saws, reciprocating saws, screw drivers, angle grinders, straight grinders, hammers, impact wrenches, angle drills, inspection cameras, and the like. Test and measurement equipment includes, for example, digital multimeters, clamp meters, fork meters, wall scanners, IR temperature guns, and the like. Vacuum cleaners include, for example, stick vacuums, hand vacuums, upright vacuums, carpet cleaners, hard-surface cleaners, canister vacuums, broom vacuums, and the like. Outdoor power equipment includes blowers, chain saws, edgers, hedge trimmers, lawn mowers, trimmers, and the like. Vehicles include, for example, automobiles, motorcycles, scooters, bicycles, and the like.

Implementations of the various techniques described herein may be implemented in digital electronic circuitry, or in computer hardware, firmware, software, or in combinations of them. Implementations may be implemented as a computer program product, i.e., a computer program tangibly embodied in an information carrier, e.g., in a machine-readable storage device, for execution by, or to control the operation of, data processing apparatus, e.g., a programmable processor, a computer, or multiple computers. A computer program, such as the computer program(s) described above, can be written in any form of programming language, including compiled or interpreted languages, and can be deployed in any form, including as a stand-alone program or as a module, component, subroutine, or other unit suitable for use in a computing environment. A computer program can be deployed to be executed on one computer or on multiple computers at one site or distributed across multiple sites and interconnected by a communication network.

Method steps may be performed by one or more programmable processors executing a computer program to perform functions by operating on input data and generating output. Method steps also may be performed by, and an apparatus may be implemented as, special purpose logic circuitry, e.g., an FPGA (field programmable gate array) or an ASIC (application-specific integrated circuit).

Processors suitable for the execution of a computer program include, by way of example, both general and special purpose microprocessors, and any one or more processors of any kind of digital computer. Generally, a processor will receive instructions and data from a read-only memory or a random access memory or both. Elements of a computer may include at least one processor for executing instructions and one or more memory devices for storing instructions and data. Generally, a computer also may include, or be operatively coupled to receive data from or transfer data to, or both, one or more mass storage devices for storing data, e.g., magnetic, magneto-optical disks, or optical disks. Information carriers suitable for embodying computer program instructions and data include all forms of non-volatile memory, including by way of example semiconductor memory devices, e.g., EPROM, EEPROM, and flash memory devices; magnetic disks, e.g., internal hard disks or removable disks; magneto-optical disks; and CD-ROM and DVD-ROM disks. The processor and the memory may be supplemented by, or incorporated in special purpose logic circuitry.

It will also be understood that when an element is referred to as being on, connected to, electrically connected to, coupled to, or electrically coupled to another element, it may be directly on, connected or coupled to the other element, or one or more intervening elements may be present. In contrast, when an element is referred to as being directly on, directly connected to or directly coupled to another element or layer, there are no intervening elements or layers present. Although the terms directly on, directly connected to, or directly coupled to may not be used throughout the detailed description, elements that are shown as being directly on, directly connected or directly coupled can be referred to as such. The claims of the application may be amended to recite exemplary relationships described in the specification or shown in the figures.

As used in this specification, a singular form may, unless definitely indicating a particular case in terms of the context, include a plural form. Spatially relative terms (e.g., over, above, upper, under, beneath, below, lower, and so forth) are intended to encompass different orientations of the device in use or operation in addition to the orientation depicted in the figures. In some implementations, the relative terms above and below can, respectively, include vertically above and vertically below. In some implementations, the term adjacent can include laterally adjacent to or horizontally adjacent to.

While certain features of the described implementations have been illustrated as described herein, many modifications, substitutions, changes and equivalents will now occur to those skilled in the art. It is, therefore, to be understood that the appended claims are intended to cover all such modifications and changes as fall within the scope of the embodiments.

What is claimed is:

1. A battery pack charger system, comprising:

a first charger configured to charge a first battery pack;

a second charger configured to charge a second battery pack;

a support member arranged between the first charger and the second charger, the support member including a platform portion configured to support the first charger and the second charger and a projecting portion extending away from the platform portion and configured to support the first battery pack and the second battery pack, the first charger attached on a first side of the support member and the second charger attached on a second side of the support member that is opposite the first side of the support member and the first side of the support member is a different side of the support member from the second side of the support member; and

a power cord configured to deliver power, the power cord being connected to one of the first charger or the second charger.

2. The battery pack charger system of claim **1**, wherein the first charger includes a first connecting structure to engage with the first battery pack and the second charger includes a second connecting structure to engage with the second battery pack, the second connecting structure being the same as the first connecting structure.

3. The battery pack charger system of claim **2**, wherein:

the first connecting structure includes guide rails configured to engage with corresponding guide rails of a slide-on style battery pack, and

the second connecting structure includes guide rails configured to engage with corresponding guide rails of a slide-on style battery pack.

4. The battery pack charger system of claim **1**, wherein the platform portion comprises:

a first pair of pedestals on the first side to be connected to a pair of screw bosses formed on the first charger; and

a second pair of pedestals on the second side to be connected to a pair of screw bosses formed on the second charger.

5. The battery pack charger system of claim **1**, wherein the platform portion includes a curved portion.

6. The battery pack charger system of claim **5**, wherein each of the first charger and the second charger includes a curved portion to correspondingly engage with the curved portion of the platform portion.

7. The battery pack charger system of claim **1**, further comprising a power brick configured to be attached to one of the first charger or the second charger.

8. The battery pack charger system of claim **7**, wherein the power brick includes guide rails to corresponding engage with guide rails of one of the first battery charger or the second battery charger when one of the first battery pack or the second battery pack is removed from the respective first charger or the second charger.

9. The battery pack charger system of claim **7**, wherein the power brick includes a recess to permit an electrical cord from the power brick to be wrapped within the recess.

10. The battery pack charger system of claim **1**, wherein the first charger and the second charger are arranged directly opposite of each other such that terminal slots on the first battery pack that engage terminal blades on the first charger face terminal slots on the second battery pack that engage terminal blades on the second charger.

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